

**IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE**

CIRBA INC. D/B/A DENSIFY
and CIRBA IP, INC.,

Plaintiffs,

v.

VMWARE, INC.,

Defendant.

Civil Action No. 1:19-cv-00742-LPS

REDACTED – PUBLIC VERSION

JURY TRIAL DEMANDED

SUPPLEMENTAL DECLARATION OF DR. VIJAY MADISETTI, Vol. II

REDACTED IN ENTIRETY

Exhibits 8-10
redacted in their
entirety

Exhibit 11

Understanding the Impact of a Noisy Neighbor Using vRealize Operations

Blue Medora (<https://blogs.vmware.com/management/author/betsygrant>) posted November 3, 2016

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By: Chuck Petrie, Blue Medora

Over the last decade there has been a huge movement towards virtual platforms to provide highly available environments while offering better utilization, performance, and functionality. A key component to virtualized environments is the sharing and distribution of physical hardware to virtual hosts and virtual machines. Although virtualizing a data center is often very advantageous it does not come without some risk to both performance and health. Today we will look at the impact of a “noisy neighbor” which is commonly defined Virtual Machine that has monopolizing resources on a Virtual Host causing issues constraints to other Virtual Machines on the same host.

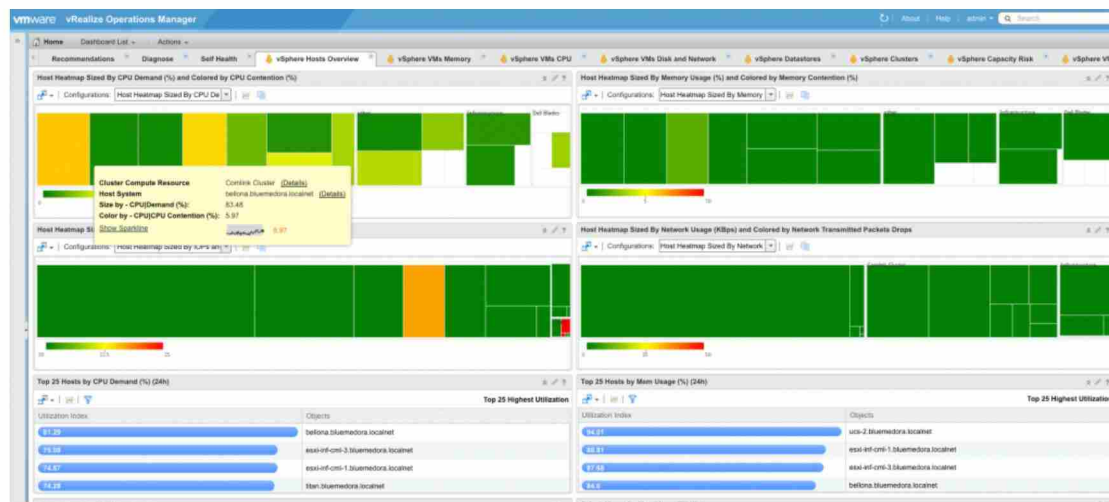


Figure 1 – vSphere Host Overview Dashboard

Using the vSphere Host Overview Dashboard provided by VMware as shown in Figure 1, we can identify CPU Contention via heatmaps. As we select the first yellow heatmap item we see that it is tied to ESXi Host bellona.bluemedora.localnet. As defined in the popup window we see that the host is running at greater than 80% CPU Demand, which is also confirmed in the Top-N widget just below the heatmap.

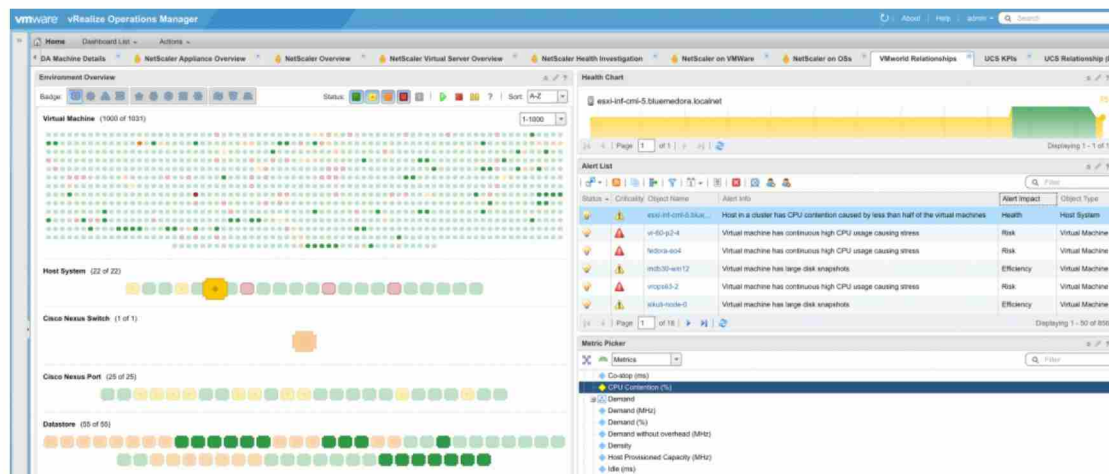


Figure 2 – Full Stack View – Custom Dashboard

PROMO



([http://www.vmware.com/go/automit-hol?](http://www.vmware.com/go/automit-hol?int_cid=70134000001CaZA&src=V)

[int_cid=70134000001CaZA&src=V](http://www.vmware.com/go/automit-hol?int_cid=70134000001CaZA&src=V)

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Ivan Ivanov posted May 3, 2018

Now that we have determined that we are seeing CPU Contention on belladonna.bluededora.localnet we can further drill down into the resource. In the summary tab we are able to see in the upper left corner that we are looking at the ESXi Host specifically. Under the health badge we see the Top Health Alert is "Host in a cluster has CPU contention caused by less than half of its virtual machines".



(<https://blogs.vmware.com/mana/capacity-utilization-vrealize-operations-6-6-dashboards.html>)

Manage Capacity and Utilization with vRealize Operations 6.6 Dashboards (<https://blogs.vmware.com/mana/capacity-utilization-vrealize-operations-6-6-dashboards.html>)

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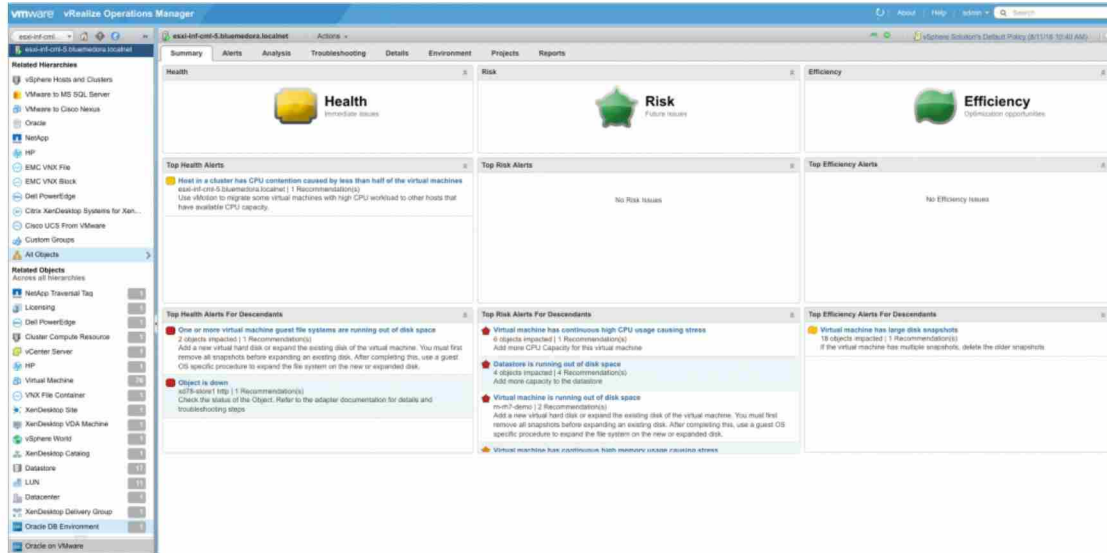


Figure 3 – Summary Tab

In conjunction to that we can see all of the top health and risk alerts for the descendants. The descendants to this particular host are listed on the left in the inventory tree. Specifically we can see that there are 76 VMs, 17 Datastores, 11 LUNs, and an Oracle DB environment (<http://www.bluededora.com/products/vrops-management-pack-for-oracle-database/>) being associated with this host. As we are seeing contention of resources on the host it is very likely that the other VMs and Oracle Environment are experience performance issues.

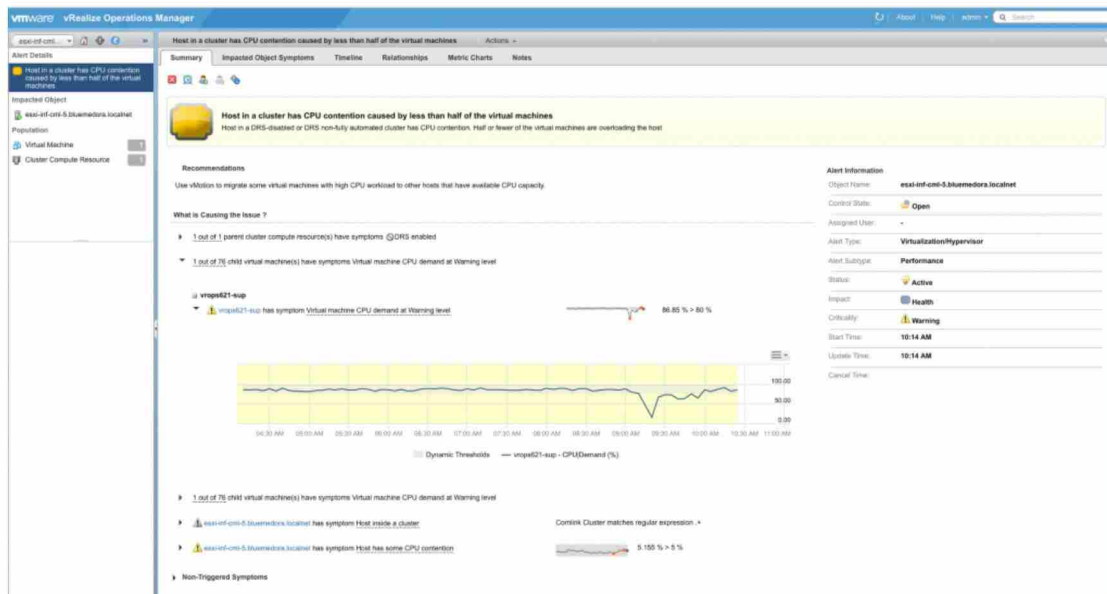


Figure 4 – Summary Alerts Tab

Drilling into the smart alert we can see the recommendation to use vMotion in order to better balance the workload. To the right we can see the alert information that this is performance led and impacting health, it is still active and was last updated at 10:14 am. From there we expand out on what is causing the issue. What we find is that VM – vrops621-sup is causing the CPU contention issue on the Host.

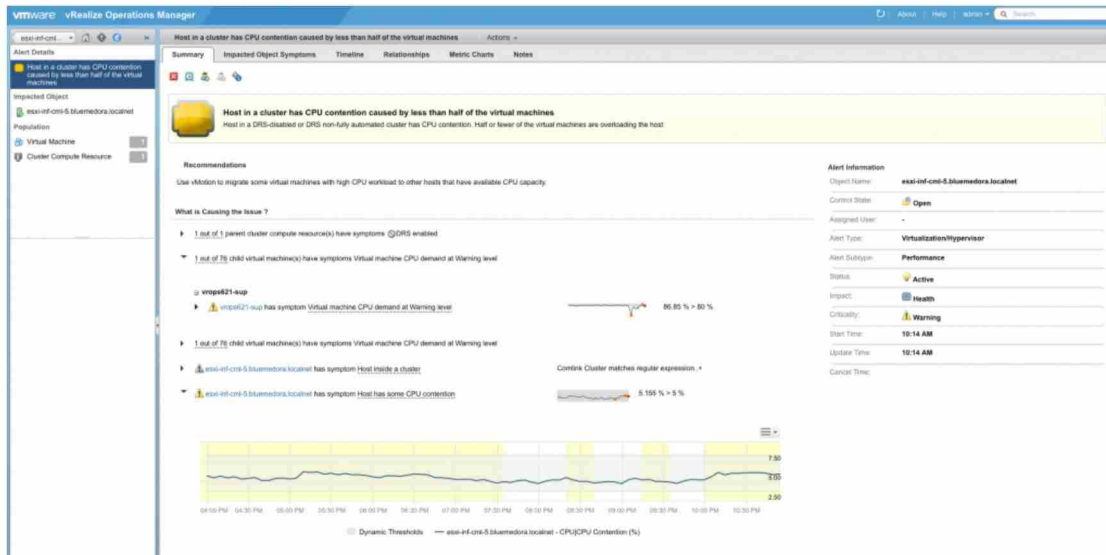


Figure 5 – Summary Alerts Tab

Expanding out the host we can see that the contention issue seems to be pretty steady across the last 24 hour period and should be address as though it is not an unusual spike in performance.

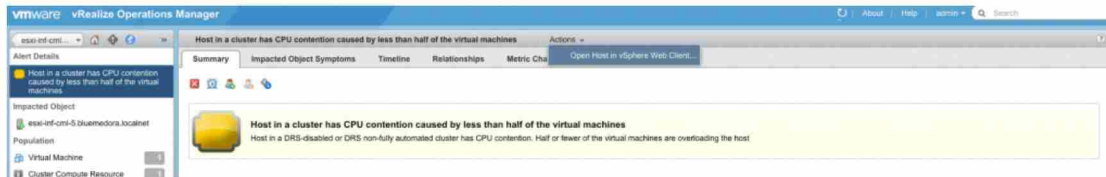


Figure 6 – Summary Alerts Tab

Now that we have identified that there is an issue, understood the impact to the business, and determined a fix based off of the root cause analysis and recommendation, we can begin to remediate the issue. In this specific case we could select the actions drop down menu and open the host within the vSphere Web Client. Once in the web client we could turn on DRS, or vMotion vrops621-sup to another host with enough resources available.

Today we used vROps to support an advanced use case of troubleshooting performance led issues created by CPU Contention on the Host. We were able to identify a problem, determine the cause, and set a path to remediate the issue. If the issue had originated at the Oracle Database, Cisco Nexus, or other layer, similar steps would be taken using vROps Management Packs by Blue Medora. For more information or a free trial, visit the product page (<http://www.bluemedora.com/products/vrops-management-pack-for-cisco-nexus/>) on Blue Medora's website (<http://bluemedora.com>).

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Exhibit 12



VMware Infrastructure

Resource Management with VMware DRS

VMware® Infrastructure 3 provides a set of distributed infrastructure services that make the entire IT environment more serviceable, available and efficient. Working with ESX Server 3, VirtualCenter 2, and VMotion™, VMware DRS (Distributed Resource Scheduler) dynamically allocates and balances computing capacity and virtual machine placement with resources pooled from multiple ESX Server hosts.

This white paper provides an architectural and conceptual overview of VMware DRS and describes how you can use DRS to simplify provisioning of applications, achieve higher levels of resource utilization, and better align use of IT resources with business values and priorities. It also describes how you can use new VMware Infrastructure capabilities such as resource pools and clusters, which allow you to allocate resources aggregated from multiple separate ESX Server hosts, but manage them with the simplicity of a single host.

This white paper covers the following topics:

- [Introduction to VMware DRS](#)
- [DRS Architecture and Conceptual Overview](#)
- [Using VMware DRS](#)
- [VMware DRS Requirements and Best Practices](#)

This white paper is intended for VMware partners, resellers, and VMware customers who want to implement virtual infrastructure solutions and want to know how to use new VMware Infrastructure features such as clusters, resource pools, and distributed infrastructure services such as VMware DRS.

Introduction to VMware DRS

With the introduction of ESX Server 3 and VirtualCenter 2, VMware extends the evolution of virtual infrastructure and virtual machines that began with the first VMware ESX Server release. ESX Server 3 and VirtualCenter 2 also introduce a revolutionary new set of infrastructure-wide services for resource optimization, high availability and data protection built on the VMware platform. These new services deliver capabilities which previously required complex or expensive solutions to implement using only physical machines. Use of these services also provides significantly higher hardware utilization and better alignment of IT resources with business goals and priorities. In the past, companies have had to assemble a patchwork of operating system or software application-specific solutions to obtain the same benefits.



VMware Infrastructure provides two new capabilities: **resource pools**, to simplify control over the resources of a host, and **clusters**, to aggregate and manage the combined resources of multiple hosts as a single collection. VMware Infrastructure virtualizes and aggregates industry-standard servers (processors, memory, their attached network and storage capacity) into logical resource pools (from a single ESX Server host or from a VMware cluster) that can be allocated to virtual machines on demand. Resource pools can be nested and organized hierarchically so that the IT environment matches company organization. In addition, individual business units can receive dedicated infrastructure while still profiting from the efficiency of resource pooling.

A set of virtualization-based distributed infrastructure services provide virtual machine monitoring and management to automate and simplify provisioning, optimize resource allocation, and provide high-availability service levels to applications at lower cost than static, physical infrastructure. One of the distributed services available, VMware DRS, dynamically allocates and balances computing capacity across the logical resource pools defined for VMware Infrastructure. VMware DRS continuously monitors utilization across the resource pools and intelligently allocates available resources among virtual machines based on resource allocation rules that reflect business needs and priorities.

Virtual machines operating within a resource pool are not tied to the particular physical server on which they are running at any given point in time. When a virtual machine experiences increased load, DRS first evaluates its priority against the established resource allocation rules and then, if justified, allocates additional resources by redistributing virtual machines among the physical servers. VMware VMotion executes the live migration of the virtual machine to a different server with complete transparency to end users. The dynamic resource allocation ensures that capacity is preferentially dedicated to the highest priority applications, while at the same time maximizing overall resource utilization.

DRS Architecture and Conceptual Overview

Before discussing the details of how VMware DRS works and how to use it to optimize resource allocation, it would be helpful to review a few basics about VMware infrastructure and some of the key elements with which VMware distributed services such as VMware DRS interact. The following sections provide some basic architectural information on VMware Infrastructure along with some of the newer features, such as clusters and resource pools, included with VMware Infrastructure 3 products.

VMware Infrastructure

At the core of VMware Infrastructure, VMware ESX Server is the foundation for delivering virtualization-based distributed services to IT environments. ESX Server provides a robust virtualization layer that abstracts processor, memory, storage and networking resources into multiple virtual machines that run side-by-side on the same physical server.

ESX Server installs directly on the server hardware, or "bare metal", and inserts a robust virtualization layer between the hardware and the operating system. ESX Server partitions a physical server into multiple secure and portable virtual machines that run on the same physical server. Each virtual machine represents a complete system—with processors, memory, networking, storage and BIOS—so that Windows, Linux, Solaris, and NetWare operating systems and software applications run in virtualized environment without any modification.

VirtualCenter, another key building block of VMware Infrastructure, manages all aspects of your virtual infrastructure—ESX Server hosts, virtual machines, provisioning, migration, resource allocations, and so on.



Figure 1 shows the architecture and typical configuration of VMware Infrastructure:

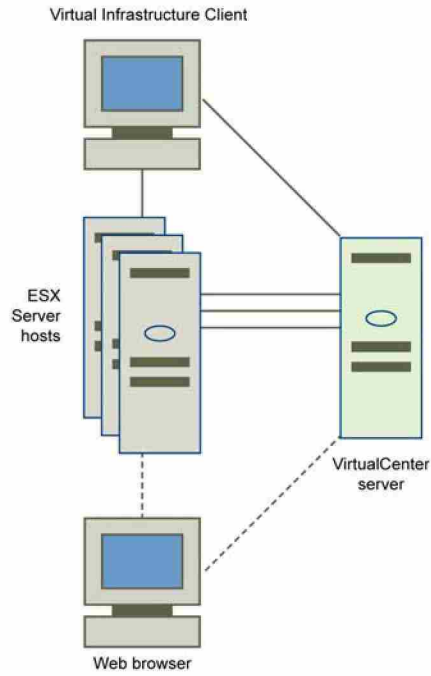


Figure 1. VMware Infrastructure Configuration

VMware Infrastructure simplifies management with a single client called the Virtual Infrastructure (VI) Client that you can use to perform all tasks. Every ESX Server configuration task from configuring storage and network connections, to managing the service console, can be accomplished centrally through the VI Client.

The VI Client connects to ESX Server hosts, even those not under VirtualCenter management, and also lets you remotely connect to any virtual machine for console access. There is a Windows version of the VI Client, and for access from any networked device, a web browser application provides virtual machine management and VMware Console access. The browser version of the client, Virtual Infrastructure Web Access, makes it as easy to give a user access to a virtual machine as sending a bookmark URL.

VirtualCenter user access controls provide customizable roles and permissions, so you create your own user roles by selecting from an extensive list of permissions to grant to each role. Responsibilities for specific VMware Infrastructure components such as resource pools can be delegated based on business organization, or ownership. VirtualCenter also provides full audit tracking to provide a detailed record of every action and operation performed on the virtual infrastructure.

Users can also access virtualization-based distributed services provided by VMotion, DRS, and HA directly through VirtualCenter and the VI client.



In addition, VirtualCenter exposes a rich programmatic Web Service interface for integration with third party system management products and extension of the core functionality:

- **VMware VMotion** enables the live migration of running virtual machines from one physical server to another. Live migration of virtual machines enables companies to perform hardware maintenance without scheduling downtime and disrupting business operations. VMotion allows the mapping of virtual machines to hosts to be continuously and automatically optimized within clusters for maximum hardware utilization, flexibility, and availability.
- **VMware DRS** works with VMotion to provide automated resource optimization and virtual machine placement and migration, to help align available resources with pre-defined business priorities while maximizing hardware utilization.
- **VMware HA** enables broad-based, cost-effective application availability, independent of hardware and operating systems.
- **VMware Consolidated Backup** provides an easy to use, centralized facility for LAN-free backup of virtual machines. Full and incremental file-based backup is supported for virtual machines running Microsoft Windows operating systems. Full image backup for disaster recovery scenarios is available for all virtual machines regardless of guest operating system.

VMware Clusters

Clusters are a new concept in virtual infrastructure management. They give you the power of multiple hosts with the simplicity of managing a single entity. A cluster is a group of loosely connected computers that work together, so that, from the point of view of aggregating resources such as CPU processing capability and memory, they can be viewed as though they are a single computer.

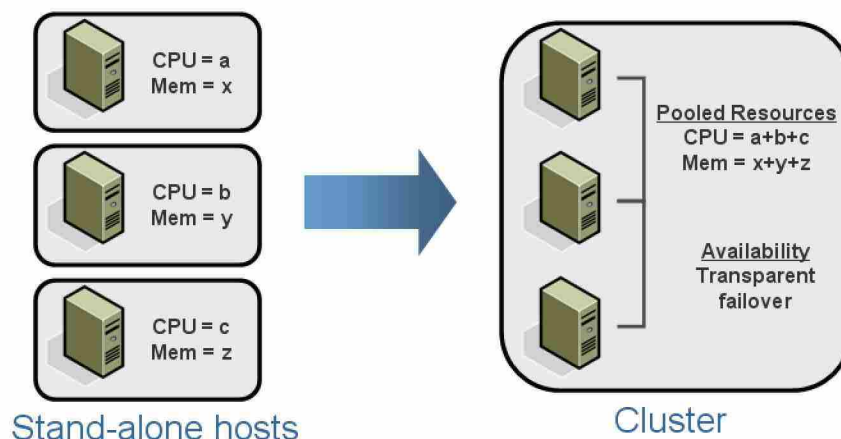


Figure 2. Resource Aggregation in VMware Clusters

VMware clusters let you aggregate the various hardware resources of individual ESX Server hosts but manage the resources as if they resided on a single host. When you power on a virtual machine, it can be given resources from anywhere in the cluster, rather than be tied to a specific ESX Server host.



VMware Infrastructure 3 provides two services to help with the management of VMware clusters: VMware HA (high availability) and VMware DRS. VMware HA allows virtual machines running on specific hosts to be switched over to use other host resources in the cluster in the case of host machine failures. VMware DRS provides automatic initial virtual machine placement and makes automatic resource relocation and optimization decisions as hosts are added or removed from the cluster or the load on individual virtual machines changes.

Resource pools can also be defined using the resources of a cluster. Defining resource pools through clusters complements efforts to align allocation of IT resources with company organization, business goals, and priorities.

Distributed Resource Scheduling

VMware DRS and VirtualCenter provide a view and management of all resources in the cluster. A global scheduler within VirtualCenter enables resource allocation and monitoring for all virtual machines running on ESX Servers that are part of the cluster.

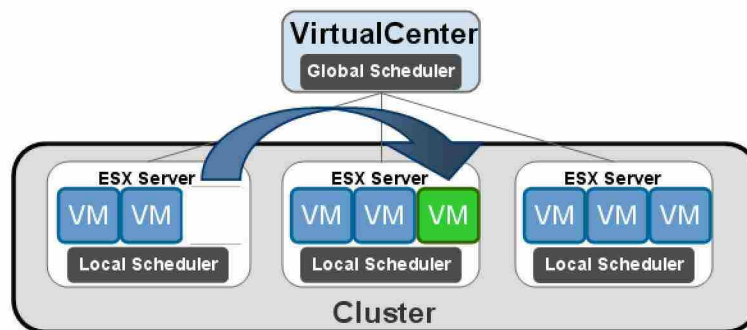


Figure 3. DRS Global Scheduler of Clusters in VirtualCenter

DRS provides automatic initial virtual machine placement on any of the hosts in the cluster, and also makes automatic resource relocation and optimization decisions as hosts or virtual machines are added or removed from the cluster. DRS can also be configured for manual control, in which case it only makes recommendations that you can review and carry out.

DRS provides several additional benefits to IT operations:

- Day-to-day IT operations are simplified as staff members are less affected by localized events and dynamic changes in their environment. Loads on individual virtual machines invariably change, but automatic resource optimization and relocation of virtual machines reduces the need for administrators to respond, allowing them to focus on the broader, higher-level tasks of managing their infrastructure.
- DRS simplifies the job of handling new applications and adding new virtual machines. Starting up new virtual machines to run new applications becomes more of a task of high-level resource planning and determining overall resource requirements, than needing to reconfigure and adjust virtual machines settings on individual ESX Server machines.
- DRS simplifies the task of extracting or removing hardware when it is no longer needed, or replacing older host machines with newer and larger capacity hardware. To remove hosts from a cluster, you can simply place them in maintenance mode, so that all virtual machines currently running on those hosts get reallocated to other resources of the cluster. After monitoring the performance of remaining systems to ensure that adequate resources remain for currently running virtual machines, you can remove the hosts from



the cluster to allocate them to a different cluster, or remove them from the network if the hardware resources are no longer needed. Adding new resources to the cluster is also straightforward, as you can simply drag and drop new ESX Server hosts into a cluster.

Before drilling down deeper into the details of how DRS works and how you can use it, it's helpful to have a better understanding of resource pools and how they use clusters.

What are Resource Pools?

Resource pools can be used to hierarchically partition available CPU and memory resources.

- Each standalone host and each DRS cluster has an (invisible) root resource pool that groups the resources of that host or cluster. The root resource pool is not displayed because the resources of the host (or cluster) and the root resource pool are always the same. If you don't create child resource pools, there are only the root resource pools.
- Users can create child resource pools of the root resource pool or of any user-created child resource pool. Each child resource pool owns some of the parent's resources and can, in turn, have a hierarchy of child resource pools to represent successively smaller units of computational capability.

A resource pool can contain child resource pools, virtual machines, or both. This creates a hierarchy of shared resources. The resource pools at a higher level are called parent resource pools, while the resource pools and virtual machines that are at the same level are called siblings. The following illustration shows an example:

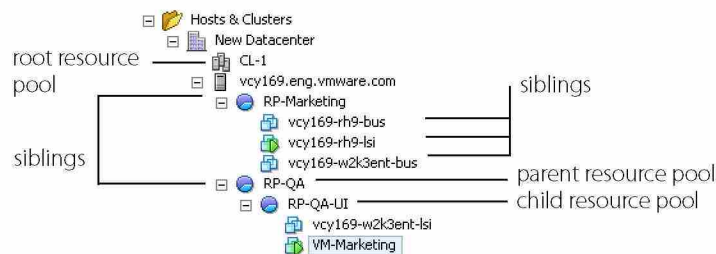


Figure 4. Resource Pool Nesting

In the example above, RP-QA is the parent resource pool for RP-QA-UI. RP-Marketing, and RP-QA are siblings. The three virtual machines immediately below RP-Marketing are also siblings.

Why Use Resource Pools?

Resource pools provide more flexibility, better hardware utilization, and more fine-grain delegation and control over resources of a host, but the benefits are especially evident when resource pools are used to compartmentalize all resources in a cluster. You can create multiple resource pools as direct children of the host or cluster and configure them, then delegate control over them to other business unit or operation managers. Using resource pools can provide the following benefits:

- Flexible hierarchical organization – You can add, remove, or reorganize resource pools or change resource allocations as needed.
- Isolation between pools, sharing within pools – Top-level administrators can make a pool of resources available to an administrator for a department. Allocation changes that are internal to one departmental resource pool do not unfairly affect other unrelated resource pools.



- Access control and delegation – When a top-level administrator makes a resource pool available to a department-level administrator, all virtual machine creation and management can then be performed by that administrator within the boundaries of the resources to which the resource pool is entitled by the current Shares, Reservation, and Limit settings.
- Separation of resources from hardware – if you are using clusters, the resources of all hosts are always assigned to the cluster. That means you can perform resource management independently of the actual host machines that contribute the resources. If you replace four 4-way hosts with four 8-way hosts, you don't need to make changes to your resource allocations. This allows administrators to think more about aggregate computing capacity and less about individual hosts.
- Management of sets of virtual machines running a distributed application – You don't need to set resources on each virtual machine. Instead, you can control the aggregate allocation of resources to the set of virtual machines by changing settings on their enclosing resource pool.

Resource Pools using Clusters

Resource pools, when used with clusters, provide easier management of large scale virtual system deployments, and enable allocation and optimization of resources aligned with an organization's business goals and priorities. The following illustration shows an example of resource pools drawing resources from a cluster:

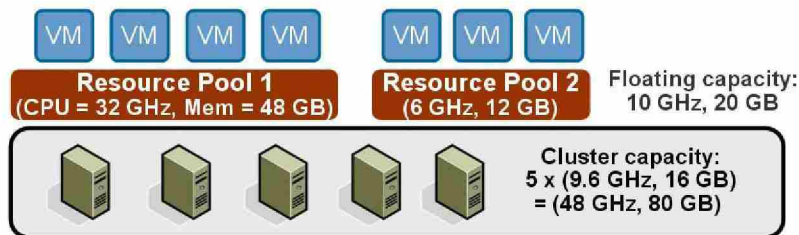


Figure 5. Resource Pools in a Cluster

In this case, five different hosts contribute resources to the cluster, with each host providing 9.6GHz processor bandwidth and 16GB memory. The total capacity of the cluster is 48GHz processor bandwidth and 80GB memory. The example shows two different resource pools. Resource Pool 1 has allocated resources of a 32GHz processor and 48GB memory. Resource Pool 2 has allocated resources of a 6GHz processor and 12GB memory.

Using DRS and VirtualCenter, virtual machines from various business units or applications can be assigned to the different resource pools, without regard for the physical hosts on which virtual machines will actually be run. In addition, the cluster has extra "floating" capacity, so additional resources are available and can be dynamically added to support virtual machines running in the resource pools, based on virtual machine load or other factors. So, a virtual machine's peak resource usage can exceed its reserved capacity by "borrowing" from extra floating cluster capacity or other "reserved" resources, if those resources are not currently being used.



Using VMware DRS

This section describes some of the setup and operation tasks you can perform using DRS and VirtualCenter: adding and removing hosts from clusters, setting up and allocating resource pools to virtual machines, and delegating resource administration to pool administrators. In addition, it describes configuration and operational controls in VirtualCenter to set VMotion automated migration levels, monitor CPU and memory usage, and perform runtime load balancing and adjustment.

Enabling DRS

VMware DRS is included as an integrated component in VMware Infrastructure 3 Enterprise. It is also available as add-on license options to VMware Infrastructure 3 Starter and VMware Infrastructure 3 Standard. To use DRS when you create VMware clusters, you need to set the Enable VMware DRS option, so that DRS can use the cluster load distribution information for initial virtual machine placement, to make load balancing recommendations, and to perform automatic runtime virtual machine migration.

For clusters enabled for DRS, the resources of all included hosts are assigned to the cluster. DRS uses the per-host resource pool hierarchies to implement the cluster-wide resource pool hierarchy. When you view the cluster using a VI Client connected to a VirtualCenter Server, you see the resource pool hierarchy implemented by DRS.

Note: When you view individual hosts using a VI Client connected to an ESX Server host, the underlying hierarchy of resource pools is presented. However, because DRS implements the most balanced resource pool hierarchy it can, you should not modify the hierarchy visible on the individual ESX Server host. If you do, DRS will undo your changes immediately for better balance if you are in automatic mode. DRS will make migration recommendations if you are in partially automatic or manual mode.

Creating a VMware Cluster

A cluster is a collection of ESX Server hosts and associated virtual machines with shared resources and a shared management interface. When you add a host to a cluster, the host's resources become part of the cluster's resources immediately, without any user intervention. When you create a cluster, you can choose to enable it for DRS, HA, or both.

Note: You can create a cluster without a special license, but you must have a license to enable a cluster for DRS or HA. In VirtualCenter 2.0.1, the maximum number of hosts that can be included in a cluster is 16.

The system must meet certain prerequisites to use VMware cluster features successfully:

- In general, DRS will work best if the virtual machines meet VMotion requirements. (See [VMware DRS Requirements and Best Practices](#), later in this white paper, for more information.)
- If you want to use DRS for load balancing, the hosts in your cluster must be part of a VMotion network. If the hosts are not in the VMotion network, DRS can still make initial placement recommendations.

VirtualCenter provides a New Cluster wizard to take you through the steps of creating a new cluster. When you first invoke the wizard, you are prompted to choose whether to create a cluster that supports VMware DRS, VMware HA, or both. That choice affects subsequent wizard pages. When you create a cluster, it initially does not include any hosts or virtual machines.



Selecting Automation Level

If you have chosen the Enable VMware DRS option, the wizard's DRS panel allows you to select the level of automation you want DRS to use regarding automatic or manual migration of virtual machines.

| Setting | Initial VM Placement | Load Balancing |
|---------------------|--------------------------------|---|
| Manual | Recommended host is displayed. | Migration recommendation is displayed. |
| Partially Automatic | Automatic placement. | Migration recommendation is displayed. |
| Automatic | Automatic placement. | Automatic execution of migration recommendations. |

Note: You can later change the level of automation for the whole cluster or for individual virtual machines. To do that, select the cluster in VirtualCenter and choose **Edit Settings** from the right-click mouse button menu. Choose the **VMware DRS** option to change settings for the entire cluster. To change settings for the individual virtual machine in the cluster, choose **VMware DRS -> Virtual Machine Options** and then right-click on a displayed virtual machine. Using the virtual machine options, you can, for example, put an individual virtual machine in manual or partially automatic mode, while the rest of the cluster is in automatic mode. It is also possible to disable DRS entirely for individual virtual machines.

After you've completed all selections for the cluster, the wizard presents a summary of the options selected. You can then complete the cluster creation.

Adding Hosts to a Cluster

The VirtualCenter inventory panel displays all clusters and hosts managed by that VirtualCenter Server. You can add a managed host to a cluster by selecting the host from either the inventory or list view and dragging the host to the target cluster object.

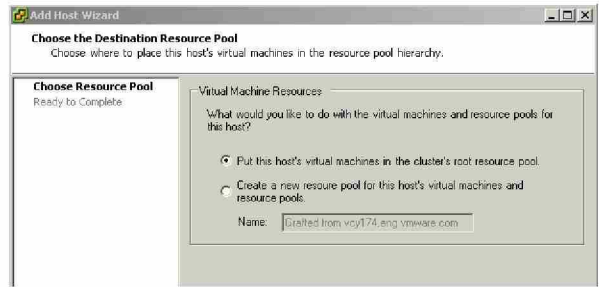


Figure 6. Adding Virtual Machines to Resource Pools

The wizard prompts to determine what you want to do with the host's virtual machines and resource pools:

- If you choose to put the host's virtual machines in the cluster's root resource, VirtualCenter makes any direct children of the host (virtual machines or resource pools) direct children of the cluster and discards the hierarchy. Any existing resource pools are removed.
- If you choose to create a new resource pool for the host's virtual machines and resource pools, VirtualCenter creates a top-level resource pool that becomes a direct child of the cluster and adds all children of the host to that new resource pool. You can supply a name for that new top-level resource pool. (The default is "grafted from *host_name*.") In this case,



the cluster keeps the grafted resource pool hierarchy if you later remove the host from the cluster. The host loses the existing resource pool hierarchy.

Note: If the host has no child resource pools or virtual machines, the host's resources are added to the cluster but no resource pool hierarchy with a top-level resource pool is created.

Adding Virtual Machines to Resource Pools

When you create a new virtual machine, the Virtual Machine Wizard in VirtualCenter allows you to select a resource pool in which to add the new virtual machine. You can also add an existing virtual machine to a resource pool by dragging or moving the virtual machine from any location in the inventory to the desired resource pool.

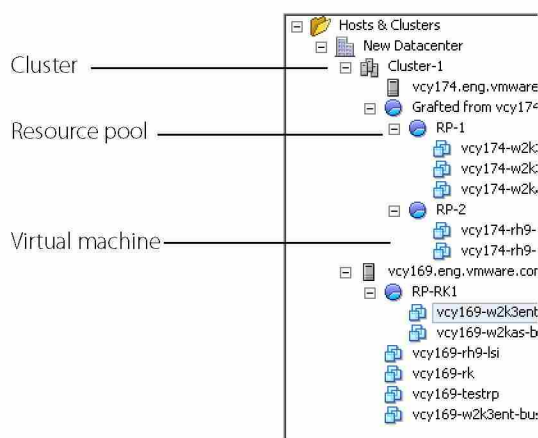


Figure 7. Cluster and Resource Pool Hierarchies

When you move a virtual machine to a new resource pool:

- The virtual machine's reservation and limit do not change.
- If the virtual machine's shares are high, medium, or low, %Shares adjusts to reflect the total number of shares in use in the new resource pool.
- If the virtual machine has custom shares assigned, the share value is maintained.

Note: If the virtual machine would receive a very large percentage of total shares, a warning is displayed.

- The information displayed in the Resource Allocation tab about the resource pool's reserved and unreserved CPU and memory resources changes to reflect the reservations associated with the virtual machine.

Note: CPU and memory, reserved and unreserved, change only if the virtual machine is powered on. If the virtual machine has been powered off or suspended, it can be moved, but overall available resources for the resource pool are not affected.

If a virtual machine is powered on, and the destination resource pool does not have enough CPU or memory to guarantee the virtual machine's reservation, the move fails because admission control does not allow it. An error dialog box compares available and requested resources, so you can consider whether an adjustment would resolve the issue.



Virtual Machine Attributes: Shares, Reservation, and Limit

For each virtual machine, you can specify Shares, Reservation (minimum) and Limit (maximum). There are other white papers posted on the VMware web site that provide more information and details of how to use these settings in different scenarios, but the following table provides a basic description of the effects these settings have on resource pools, particularly those defined using DRS-enabled clusters.

| Setting | Description |
|-------------|---|
| Shares | The relative priority or importance of a virtual machine. If a virtual machine has twice as many shares for a resource as another virtual machine, it is entitled to consume twice as much of that resource. Shares are typically specified as high, normal, or low, using a 4:2:1 ratio. You can also choose Custom to assign a specific number of shares expressing a proportional weight to each virtual machine. Specifying shares makes sense only with regard to sibling virtual machines or resource pools, that is, virtual machines or resource pools with the same parent in the resource pool hierarchy. Siblings share resources according to their relative share values, bounded by the reservation and limit. When you assign shares to a virtual machine, you always specify the relative priority for that virtual machine. |
| Reservation | The guaranteed reservation for the virtual machine. When you attempt to power on a virtual machine, the virtual machine is only allowed to power on if the CPU and memory reservation is available and that amount of CPU and memory can be guaranteed even under heavy loads. Reservation defaults to 0. It is often a good idea to specify a reservation to guarantee that the necessary CPU or memory are always available for the virtual machine. |
| Limit | The upper limit for CPU or memory for a virtual machine. That is, more resources can be allocated to a virtual machine than the reservation amount, however, the allocated resources will never exceed the specified limit . The limit is expressed in concrete units (MHz or MB). CPU and memory limit default to unlimited. In that case, the amount of memory you assigned to the virtual machine when you created it becomes the virtual machine's memory. In most cases, it's not necessary to specify a limit. There are pros and cons for specifying a limit. On the plus side, assigning a limit can be useful if you start with a small number of virtual machines and want to manage user expectations; performance will deteriorate somewhat as you add more virtual machines, so you can simulate having fewer resources initially available by specifying a limit. The down side is that you might waste idle resources if you specify a limit, since virtual machines are not allowed to use more resources than the limit, even when the system is under-utilized and idle resources are available. You should therefore specify a limit only if there are good reasons for doing so. |

Note: These settings are also used for resource pools.



Creating and Managing Resource Pools for DRS-Enabled Clusters

For clusters enabled for DRS, you can also create child resource pools of the cluster. When you create a child resource pool, you are prompted for resource pool attribute information. The system uses admission control to make sure you don't allocate resources that aren't available. After selecting the intended parent and choosing the New Resource Pool option, you can specify information listed in the following table for a new resource pool:

| Field | Description |
|--------------------------|---|
| Name | Name of the new resource pool. |
| CPU Resources: | |
| Shares | Number of CPU shares the resource pool has with respect to the parent's total. Sibling resource pools share resources according to their relative share values bounded by the reservation and limit. You can choose Low, Normal, or High, or choose Custom to specify a number that assigns a share value. |
| Reservation | Guaranteed CPU allocation for this resource pool. |
| Expandable Reservation | Use this check box to indicate that, if virtual machines are powered on in this resource pool, and the reservations of the virtual machines combined are larger than the reservation of the resource pool, the resource pool can use a parent's or ancestor's resources. Default is checked. |
| Limit | Upper limit for the amount of CPU the host makes available to this resource pool. Default is Unlimited. To specify a limit, uncheck the Unlimited check box and type in the number. |
| Memory Resources: | |
| Shares | Number of memory shares the resource pool has with respect to the parent's total. Sibling resource pools share resources according to their relative share values bounded by the reservation and limit. You can choose Low, Normal, or High, or choose Custom to specify a number that assigns a share value. |
| Reservation | Guaranteed memory allocation for this resource pool. |
| Expandable Reservation | Use this check box to indicate that more than the specified reservation should be allocated if resources are available in a parent. |
| Limit | Upper limit for this resource pool's memory allocation. Default is Unlimited. To specify a different limit, uncheck the Unlimited check box. |

When you power on a virtual machine or create a resource pool, the system checks whether the CPU and memory reservation is available for that action. If **Expandable Reservation** is not checked, the system considers only the resources available in the selected resource pool.

If **Expandable Reservation** is checked (the default), the system considers both the local resource pool and those of ancestors when performing admission control (deciding whether to allow a virtual machine to be powered on). Ancestors includes direct parents, parents of the parents, and so on. For ancestors, resources can only be used if the ancestor pool is set to **expandable** and no Limit is set that would stop it from borrowing more resources. Leaving the expandable option checked offers more flexibility, but, at the same time provides less protection from a child resource pool owner potentially reserving more resources than anticipated.

If any of the selected values are not legal values, because of limitations on total available CPU and memory, a yellow triangle is displayed to indicate so, and you cannot enter values larger than the legal values. For example, if you have a resource pool with a reservation of 10GB, and you created a child resource pool with a reservation of 6GB, you cannot create a second child resource pool with a reservation of 6MB and Type set to Fixed.



Admission Control

When you power on virtual machines inside a resource pool, or attempt to create a child resource pool, the system checks to ensure the resource pool's restriction and limit settings are not violated.

Before you power on a virtual machine or create a resource pool, you can check the CPU Unreserved and Memory Unreserved fields in the resource pool's Resource Allocation tab to see whether sufficient resources are available for your needs.

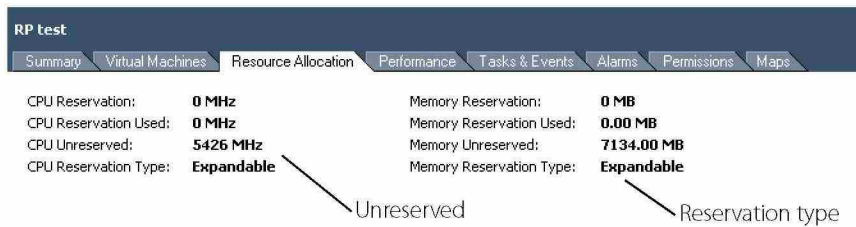


Figure 8. Resource Allocation Information

How unreserved CPU and memory are computed depends on the Reservation Type:

- If the Reservation Type is Fixed, the system checks whether the resource pool has sufficient unreserved resources. If it does, the action can be performed. If it does not, a message appears and the action cannot be performed.
- If the Reservation Type is Expandable, the system first checks whether the resource pool has sufficient resources to fulfill the requirements. If there are sufficient resources, the action is performed.
- If there are not sufficient resources, the managing server checks whether resources are available in a parent resource pool (direct parent or ancestor). If there are, the action is performed and the parent resource pool resources are reserved. If no resources are available, a message appears and the action is not performed.

When you power on a virtual machine on a host that is part of a DRS-enabled cluster, VirtualCenter does the following:

1. VirtualCenter performs admission control (that is, it checks whether the cluster or resource pool has enough resources for the virtual machine to be powered on).
2. VirtualCenter checks whether there's a host in the cluster that has enough resources for powering on the virtual machine. This must be a single host. It's not enough that two hosts jointly have sufficient resources. If there are not sufficient resources, a message appears. Otherwise, VirtualCenter proceeds as follows:
 - If DRS is in Manual mode, VirtualCenter displays a list of recommended hosts ordered from best to worst. You can choose one of the hosts.
 - If DRS is in Partially Automatic or Automatic mode, VirtualCenter places the virtual machine on the most suitable host.

Admission control is performed whenever you power on a virtual machine or create a resource pool. It is also performed whenever you modify the Reservation or Limit settings or when you change the structure of the resource pool hierarchy.



Viewing Resource Pool Information

When you select a resource pool in the VirtualCenter display, the Summary tab displays high-level statistical information about the resource pool.

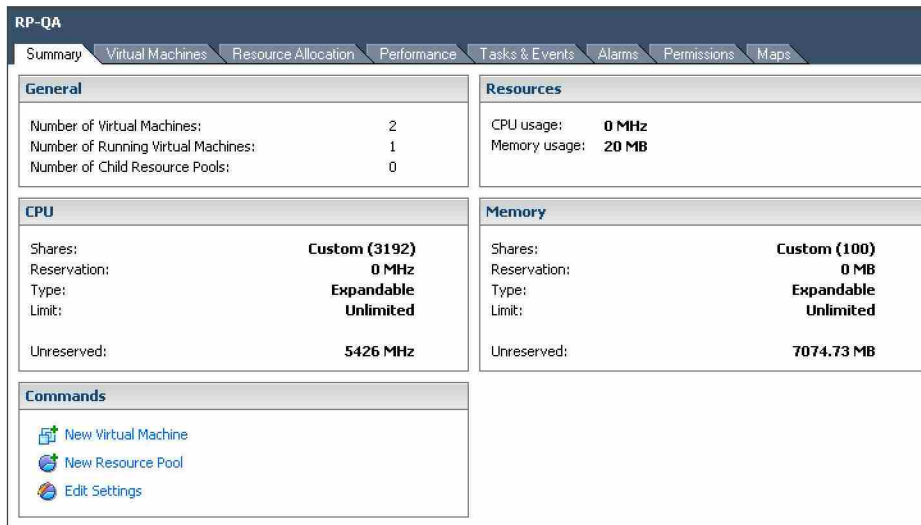


Figure 9. Viewing Resource Pool Information

The following table describes items included in the summary:

| Section | Description |
|-----------|---|
| General | <p>The General panel displays statistical information for the resource pool.</p> <ul style="list-style-type: none"> • Number of Virtual Machines — Number of virtual machines in this resource pool. Does not include the number of virtual machines in child resource pools. • Number of Running Virtual Machines — Number of running virtual machines in this resource pool. Does not include the number of virtual machines running in child resource pools. • Number of Child Resource Pools — Number of direct child resource pools. Does not include all resource pools in the hierarchy but only direct children. |
| CPU | Displays the CPU Shares, Reservation, Reservation Type, and Limit that were specified for this resource pool. Also displays the amount of CPU currently unreserved. |
| Commands | <p>Allows you to invoke commonly used commands.</p> <ul style="list-style-type: none"> • New Virtual Machine — Starts the New Virtual Machine wizard to create a new virtual machine in this resource pool. • Create Resource Pool — Displays the Create Resource Pool dialog, which allows you to create a child resource pool of the selected resource pool. • Edit Settings — Allows you to change the CPU and memory attributes for the selected resource pool. |
| Resources | Displays CPU Usage and Memory Usage for the virtual machines within the selected resource pool. |
| Memory | Displays the Memory Shares, Reservation, Reservation Type, and Limit that were specified for this resource pool. Also displays the amount of memory currently unreserved. |



The resource pool's Resource Allocation tab gives detailed information about the resources currently reserved and available for the resource pool, and lists the user of the resources as described in the tables below:

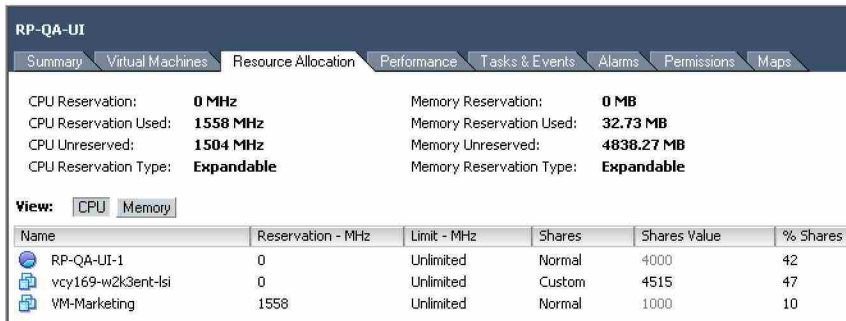


Figure 10. Resource Pool Allocation Information

The top portion of the display specifies information about the resource pool itself:

| Field | Description |
|--|---|
| CPU Reservation/ Memory Reservation | Amount of CPU or memory specified in the reservation for this resource pool. The reservation can be specified during resource pool creation, or later by editing the resource pool. |
| CPU Reservation Used/ Memory Reservation Used | CPU or memory reservation used. Reservations are used by running virtual machines or by child resource pools with reservations. |
| CPU Unreserved / Memory Unreserved | CPU or memory currently unreserved and available to be reserved by virtual machines and resource pools. Look at this number when trying to determine whether you can create a child resource pool of a certain size, or whether you can power on a virtual machine with a certain reservation. |
| Reservation Type | Expandable or Fixed. |

Below the resource pool specific information is a list of the resource pool's virtual machines and child resource pools of this resource pool.

Note: This table does not list virtual machines assigned to child resource pools of this resource pool.

You can click the CPU or Memory tab to display the following information:

| Field | Description |
|--------------|--|
| Name | Name of the resource pool or virtual machine. |
| Reservation | Specified reservation for this virtual machine or resource pool. Default is 0, that is, the system reserves no resources for this resource pool. |
| Limit | Specified limit for this virtual machine or resource pool. Default is Unlimited, that is, the system allocates as many resources to this virtual machine as it can. |
| Shares | Specified shares for this virtual machine or resource pool. Choose High, Normal, or Low, if one of the default settings has been selected, or Custom, if a custom setting has been selected. |
| Shares Value | Number of shares allocated to this virtual machine or resource pool. This number depends on the Shares setting (High, Medium, Low, or Custom). |



| Field | Description |
|---------|---|
| %Shares | Shares value for this resource pool or virtual machine divided by the total number of Shares in parent resource pool. |
| Type | Reservation type. Either Fixed or Expandable. |

Monitoring Resource Pool Performance

Monitoring a resource pool's performance is useful if you want to understand the effectiveness of resource pool allocations. To monitor a resource pool's performance, select the resource pool in the inventory panel and click the Performance tab. VirtualCenter displays information about resource pool performance. You can click Change Chart Options to customize the performance chart.

Viewing Cluster Information

When you select a cluster from the VirtualCenter inventory panel, the Summary page displays high-level information about the selected cluster.

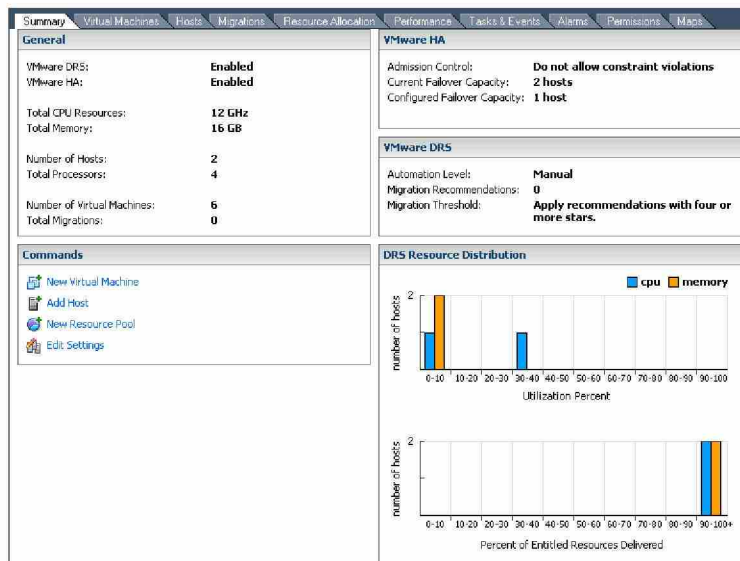


Figure 11. Viewing Cluster Information

The Summary page provides information about the cluster and the virtual machines assigned to the cluster. For clusters enabled for DRS, the Summary page displays automation level and migration threshold settings, outstanding migration recommendations and real-time histograms of "Utilization Percent" and "Percent of Entitled Resources Delivered" to show how balanced the cluster is. Migration recommendations are displayed if you select the Migrations tab. (Automation level and migration threshold are set during cluster creation.)



Cluster Status Information

As hosts and virtual machines are added or removed, clusters can become overcommitted or invalid because of HA or DRS violations. Messages displayed on the Summary page displays the status of the currently selected cluster.

The Virtual Infrastructure Client indicates whether a cluster is valid (green), overcommitted (yellow), or invalid (red).

Green (Valid) Cluster

A cluster is considered valid unless something happens that makes it overcommitted or it no longer satisfies failover capacity requirements. For example, a DRS cluster can become overcommitted if a host fails. A DRS cluster can also become invalid if VirtualCenter becomes unavailable and you power on virtual machines using a VI Client connected directly to an ESX Server host.

If a cluster is valid, this indicates there are enough resources to meet all reservations and to support all running virtual machines. In addition, there is at least one host with enough resources to run each virtual machine assigned to the cluster. If you use a particularly large virtual machine (for example, a virtual machine with an 8GB reservation), you must have at least one host with that much memory. It's not enough if two hosts together fulfill the requirement.

Yellow (Overcommitted) Cluster

A cluster becomes yellow when the tree of resource pools and virtual machines is internally consistent but the user has allowed violation of certain requirements. This happens when capacity is removed from the cluster because, for example, a host fails or is removed and there are no longer enough resources to support all requirements.

Red (Invalid) Cluster

A cluster becomes red when the tree is no longer internally consistent and does not have enough resources available. As a rule, this could happen if you use a VI Client connected to an ESX Server host to start a virtual machine while VirtualCenter is not available. As soon as VirtualCenter becomes available again, it detects the additional use of resources and marks that branch of the tree red. You can remedy the problem either by powering off one or more virtual machines or by adding resources. Until you have remedied the problem, you cannot allocate resources on the red branch of the tree, and DRS will not make any recommendation or migrate virtual machines automatically. As a result, the cluster is likely to become progressively more imbalanced.

Managing DRS

When you enable a cluster for DRS, VirtualCenter continuously monitors the distribution of CPU and memory resources for all hosts and virtual machines in the cluster. DRS compares these metrics to the ideal resource utilization, given the attributes of the resource pools and virtual machines in the cluster and the current load. DRS evaluates both the specified configuration settings and the current load.

Initial Placement

When you power on a virtual machine, VirtualCenter first checks that there are enough resources in the cluster to support that specific virtual machine. VirtualCenter then finds a host on which the virtual machine can run.

- If the cluster is manual, VirtualCenter displays a list of recommended hosts.
- If the cluster is partially automatic or automatic, VirtualCenter places the virtual machine on the appropriate host.



Virtual Machine Migration

When a cluster enabled for DRS becomes unbalanced, DRS makes recommendations or migrates virtual machines depending on the automation level:

- If the cluster is manual or partially automated, VirtualCenter does not take automatic actions to balance resources. Instead, the Summary page indicates that migration recommendations are available and the Migration page displays recommendations for the most efficient use of resources across the cluster.
- If the cluster is fully automated, VirtualCenter places virtual machines that join the cluster on appropriate hosts and migrates running virtual machines between hosts, as needed, to ensure the best possible use of cluster resources. VirtualCenter displays a history of migrations in the Migration tab.

Note: Even in an automatic migration setup, users can explicitly migrate individual virtual machines as they want, but VirtualCenter might move those virtual machines to other hosts to optimize cluster resources. By default, an automation level is specified for the whole cluster. You can also specify a custom automation level for individual virtual machines.

Setting the Migration Threshold

The migration threshold allows you to specify which recommendations are automatically applied when the cluster is in fully automated mode.

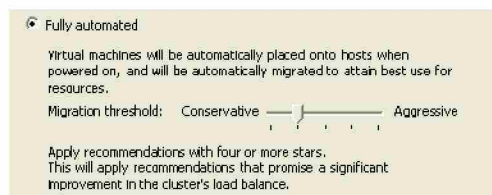


Figure 12. Migration Threshold Settings

You can move the slider to use one of five levels:

- **Level 1** – Apply only five-star recommendations. Includes recommendations that must be followed to satisfy cluster constraints, such as affinity rules and host maintenance. This level indicates a mandatory move, required to satisfy an affinity rule or evacuate a host that is entering maintenance mode.
- **Level 2** – Apply recommendations with four or more stars. Includes Level 1 plus recommendations that promise a significant improvement in the cluster's load balance.
- **Level 3** – Apply recommendations with three or more stars. Includes Level 1 and 2 plus recommendations that promise a good improvement in the cluster's load balance.
- **Level 4** – Apply recommendations with two or more stars. Includes Level 1-3 plus recommendations that promise a moderate improvement in the cluster's load balance.
- **Level 5** – Apply all recommendations. Includes Level 1-4 plus recommendations that promise a slight improvement in the cluster's load balance.

Note: See [VMware DRS Requirements and Best Practices](#), later in this white paper, for some more specific examples and guidelines on setting migration thresholds.



Following Migration Recommendations

If you create a cluster in manual or partially automated mode, VirtualCenter displays migration recommendations on the Migrations page. The system supplies as many recommendations as necessary to properly balance the resources of the cluster. Each recommendation includes a priority, the virtual machine to be moved, current (source) host and target host, CPU load and memory load, and a reason for the recommendation.

| Migration Recommendations | | | | | | |
|---------------------------|-----------------|----------------------------|-----------------|-----------------|----------------------------------|------------------------------|
| Priority | Virtual Machine | Reason | Source Host | Target Host | CPU Load | Memory Load |
| ★★★★★ | test06 | Satisfy anti-affinity rule | vsuiqa010.en... | vsuiqa012.en... | source: 6019 MHz, target: 24 MHz | source: 2 GB, target: 511 MB |
| ★★★★★ | test01 | Balance average CPU loads | vsuiqa010.en... | vsuiqa012.en... | source: 6019 MHz, target: 24 MHz | source: 2 GB, target: 511 MB |
| ★★★★★ | test02 | Balance average CPU loads | vsuiqa010.en... | vsuiqa012.en... | source: 6019 MHz, target: 24 MHz | source: 2 GB, target: 511 MB |
| ★★★ | test08 | Balance average CPU loads | vsuiqa010.en... | vsuiqa012.en... | source: 6019 MHz, target: 24 MHz | source: 2 GB, target: 511 MB |

Apply Migration Recommendation

Figure 13. Migration Recommendations

Migrations that are all part of the same recommendation (for example because of DRS affinity) are indicated by a link icon.

At times, a virtual machine is part of a recommendation involving multiple virtual machines (for example, if the machine is part of an affinity or anti-affinity group). If you select such a virtual machine and the dependent virtual machines are not part of the selection, a warning dialog box asks whether you want to include the dependent virtual machines in this set of migrations.

Using DRS Affinity Rules

After you have created a DRS cluster, you can edit its properties to create rules that specify affinity. You can use these rules to specify that:

- DRS should try to keep certain virtual machines together on the same host, for example, to optimize performance.
- DRS should try to make sure that certain virtual machines are not together, for example, for high availability. You might want to guarantee certain virtual machines are always on different physical hosts. When there's a problem with one host, you don't lose both virtual machines.

Note: These rules are completely different from an individual host's CPU affinity rules. In general, don't specify affinity rules unless you have specific reasons to do so. This will give DRS the maximum flexibility to consider all options for resource management and hence enable the most efficient resource placement. See [VMware DRS Requirements and Best Practices](#), later in this white paper, for some specific examples of affinity rule application.



To create a DRS rule, select the cluster in VirtualCenter and choose **Edit Settings** from the right-click mouse button menu. In the Cluster Settings dialog box, choose the **Rules** option to define a new rule.

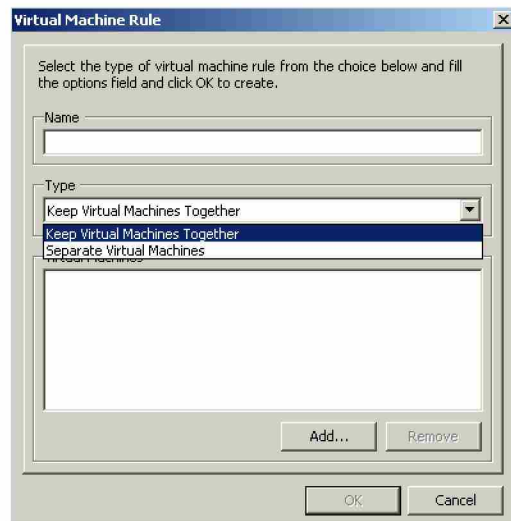


Figure 14. Adding DRS Affinity Rules

From the pop-up menu, choose one of the following options:

- Keep Virtual Machines Together
- Separate Virtual Machines

After you've added the rule, you can edit it, look for conflicting rules, or delete it.

When you add or edit a rule, and the cluster is immediately in violation of that rule, the system continues to operate and tries to correct the violation. For manual and partly automated DRS clusters, migration recommendations are based on both rule fulfillment and load balancing. You are not required to fulfill the rules, but the corresponding recommendations remain until the rules are fulfilled.

Host Removal and Virtual Machines

Both standalone hosts and hosts within a cluster support a Maintenance Mode, which restricts virtual machine operations on the host to allow the user to conveniently shut down running virtual machines in preparation for host shutdown. While in maintenance mode, the host does not allow you to deploy or power on new virtual machines. Virtual machines that are already running on the host continue to run normally. You can either migrate them to another host or shut them down. When there are no more running virtual machines on the host or cluster, its icon changes and its Summary indicates the new state. In addition, menu and command options involving virtual machine deployment are disabled when this host or cluster is selected.

Because a host must be in maintenance mode before you can remove it from a cluster, all virtual machines must be powered off first (unless DRS is also enabled, in which case virtual machines are automatically removed from the host). When you then remove the host from the cluster, the virtual machines that are currently associated with the host are also removed from the cluster.



Removing Hosts with Virtual Machines from a Cluster

If you remove a host from a cluster, the available resources for the cluster decrease. When you remove a host with virtual machines from a cluster, all its virtual machines are removed as well. You can remove a host only if it is in maintenance mode or disconnected.

If the cluster is enabled for DRS, host removal can have the following effect:

- If there are still enough resources to satisfy the reservations of all virtual machines and resource pools in the cluster, the cluster adjusts resource allocation to reflect the reduced amount of resources.
- If there are not enough resources to satisfy the reservations of all resource pools, but there are enough resources to satisfy the reservations for all virtual machines, an alarm is issued and the cluster is marked yellow.

Removing Virtual Machines from a Cluster

You can remove virtual machines by migrating them out of a cluster or by removing a host with virtual machines from the cluster.

You can migrate a virtual machine from a cluster to a standalone host, or from one cluster to another cluster, by using the standard drag-and-drop method or by selecting **Migrate** from the virtual machine's right-button menu or the VirtualCenter menu bar. If the cluster is DRS-enabled and the virtual machine is a member of a DRS cluster affinity rules group, VirtualCenter displays a warning before it allows the migration to proceed. The warning indicates that dependent virtual machines are not migrated automatically, so you have to acknowledge the warning before migration can proceed.

VMware DRS Requirements and Best Practices

Using VMware DRS helps simplify the setup and management of large virtual infrastructure deployments by allowing users to perform administration on a single entity, the cluster. However, for best results, your virtual infrastructure systems should also meet certain prerequisites so that VMware cluster features operate properly:

- In general, DRS will work best if the virtual machines meet VMotion requirements, as discussed in the next section.
- If you want to use DRS for load balancing, the hosts in your cluster must be part of a VMotion network. If the hosts are not in the VMotion network, DRS can still make initial placement recommendations.

VirtualCenter VMotion Requirements

To be configured for VMotion, each host in the cluster must meet the following requirements.

Shared Storage

Ensure that the managed hosts use shared storage. Shared storage is typically on a storage area network (SAN). See the *VMware SAN Configuration Guide* and the *VMware Infrastructure Server Configuration Guide* for additional information.

Shared VMFS Volume

Configure all of your managed hosts to use shared Virtual Machine File System (VMFS) volumes.

- Place the disks of all virtual machines on VMFS volumes that are accessible by both source and target hosts.



- Set access mode for the shared VMFS to “public”.
- Ensure the VMFS volume is sufficiently large to store all of the virtual disks for your virtual machines.
- Ensure all VMFS volumes on your source and destination hosts use volume names, and all virtual machines use those volume names for specifying the virtual disks.

Note: Virtual machine swap files also need to be on a VMFS accessible to both source and destination hosts.

Processor Compatibility

Ensure that the source and destination hosts have a compatible set of processors. VMotion transfers the running architectural state of a virtual machine between underlying VMware ESX Server systems. VMotion compatibility therefore means that the processors of the target host must be able to resume execution using the equivalent instructions, from the point where the processors of the source host were suspended.

Processor clock speeds and cache sizes might vary, but processors must be from the same vendor class (Intel vs. AMD) and same processor family to be compatible for migration with VMotion. Processor families, such as Xeon MP and Opteron, are defined by the processor vendors. Different versions within the same processor family can be distinguished by comparing a processor's model, stepping level, and extended features. In addition:

- In most cases, different processor versions within the same family are similar enough to maintain compatibility.
- In some cases, processor vendors have introduced significant architectural changes within the same processor family (such as 64-bit extensions and SSE3). VMware identifies these exceptions if it cannot guarantee successful migration with VMotion.

Note: VMware works on maintaining VMotion compatibility across the widest range of processors through partnerships with processor and hardware vendors. For current information, contact your VMware representative.

Miscellaneous Virtual Machine, VMFS, and VMotion Requirements

There are a few other specific VMware Infrastructure requirements to be aware of when using DRS:

- For ESX Server 3, the virtual machine configuration file for ESX Server hosts must reside on a VMFS.
- VMotion does not currently support raw or undoable virtual disks or migration of applications clustered using Microsoft Cluster Service (MSCS).
- VMotion requires a Gigabit Ethernet network between hosts.
- VMotion requires the setup of a private, Gigabit Ethernet migration network between all of the VMotion-enabled managed hosts. When VMotion is enabled on a managed host, configure a unique network identity object for the managed host and connect it to the private migration network.



Resource Management and DRS Best Practices

The following guidelines can help you achieve optimal performance for your virtual machines:

- If you expect frequent changes to the total available resources, use Shares, not Reservation, to allocate resources fairly across virtual machines. If you use Shares and you upgrade the host, each virtual machine stays at the same priority (keeps the same number of shares) even though each share represents a larger amount of memory or CPU.
- Use Reservation to specify the minimum acceptable amount of CPU or memory, not the amount you would like to have available. The host assigns additional resources as available based on the number of Shares and the Limit for your virtual machine.
- Use Reservations to specify the minimum reservation for each virtual machine. In contrast to Shares, the amount of concrete resources represented by a reservation does not change when you change the environment, for example, by adding or removing virtual machines.
- Don't set Reservation too high. A reservation that's too high can limit the number of virtual machines in a resource pool.
- When specifying the reservations for virtual machines, always leave some headroom; do not commit all resources. As you move closer to fully reserving all capacity in the system, it becomes increasingly difficult to make changes to reservations and to the resource pool hierarchy without violating admission control. In a DRS-enabled cluster, reservations that fully commit the capacity of the cluster or of individual hosts in the cluster can prevent DRS from migrating virtual machines between hosts.
- Use resource pools for delegated resource management. To fully isolate a resource pool, make the resource pool type Fixed and use Reservation and Limit.
- Group virtual machines for a multi-tier service in a resource pool. This allows resources to be assigned for the service as a whole.
- Affinity rules
 - In general, don't specify affinity rules unless you have specific reasons to do so. This will give DRS the maximum flexibility to consider all options for resource management and hence enable the most efficient resource placement.
 - Reason to select **Keep Virtual Machines Together**: The virtual machines are known to communicate a lot with each other over the network. If the virtual machines reside on the same host, then all network communication takes place over a virtual switch, which is much faster than a physical switch and doesn't use any physical network resources.
 - Reason to select **Separate Virtual Machines**: You want to maximize availability of the virtual machines. For example, if the virtual machines both provide a web server front end to the same application, you wouldn't want both virtual machines to go down at the same time, in the event that the physical host on which they reside goes down.
- When a list of recommendations is made for a cluster in manual mode, the recommendations should be applied in order. Otherwise, performance results could potentially be slightly worse than the initial state.



- The migration threshold for clusters should be set to more aggressive levels (towards 5) in the following cases:
 - if the hosts in the cluster are relatively homogeneous.
 - if the virtual machine's resource utilization does not vary too much over time.
 - if you have relatively few constraints on where a virtual machine can be placed, such as VSMP requirements, large memory requirements, specific virtual network configurations, access to specific datastores, etc.
- The migration threshold for clusters should be set to more conservative levels in the reverse situations to those listed above.
- When deciding which hosts to group into a DRS cluster, try to choose hosts that are as homogeneous as possible, in terms of CPU, memory, and storage, to allow the most flexible management of resources.

Summary

VMware DRS, along with the capabilities of clusters and resource pools, greatly simplifies virtual machine provisioning, resource allocation, load balancing, migration, and the overall management of large virtual infrastructure installations. Providing the capability to aggregate resources pooled from multiple ESX Server hosts allows companies to achieve higher levels of resource availability and utilization, while managing multiple ESX Servers in a cluster, with the simplicity of a single host. In addition, resource pools allow better alignment of IT resources with a company's own organizational structure, business priorities, and values. Access control granularity lets top-level administrators delegate selected permissions and control to business function and department-level administrators for resource pools and the associated virtual machines and applications for which they are responsible.

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Exhibits 13-15 redacted
in thier entirety

Exhibit 16

vSphere Virtual Machine Administration

Update 1

16 OCT 2018

VMware vSphere 6.7

VMware ESXi 6.7

vCenter Server 6.7



vmware®

You can find the most up-to-date technical documentation on the VMware website at:

<https://docs.vmware.com/>

If you have comments about this documentation, submit your feedback to

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Contents

About vSphere Virtual Machine Administration 6

Updated Information 8

1 Introduction to VMware vSphere Virtual Machines 9

Virtual Machine Files 9

Virtual Machines and the Virtual Infrastructure 10

Virtual Machine Lifecycle 11

Virtual Machine Components 11

Virtual Machine Hardware Available to vSphere Virtual Machines 13

Virtual Machine Options 15

The vSphere Client and the vSphere Web Client 16

Where to Go From Here 17

2 Deploying Virtual Machines 18

Create a Virtual Machine with the New Virtual Machine Wizard 19

Clone a Virtual Machine to a Template 22

Clone a Virtual Machine to a Template in the vSphere Web Client 25

Deploy a Virtual Machine from a Template 28

Deploy a Virtual Machine from a Template in the vSphere Web Client 32

Clone an Existing Virtual Machine 35

Clone an Existing Virtual Machine in the vSphere Web Client 40

Cloning a Virtual Machine with Instant Clone 44

Clone a Template to a Template 45

Clone a Template to a Template in the vSphere Web Client 48

Convert a Template to a Virtual Machine 51

3 Deploying OVF and OVA Templates 53

OVF and OVA File Formats and Templates 53

Deploy an OVF or OVA Template 54

Export an OVF Template 56

Browse VMware Virtual Appliance Marketplace 56

4 Using Content Libraries 58

Create a Library 60

Synchronize a Subscribed Content Library 62

Edit a Content Library 62

Hierarchical Inheritance of Permissions for Content Libraries 65

| | |
|---|----|
| Content Library Administrator Role | 67 |
| Populating Libraries with Content | 68 |
| Working with Items in a Library | 72 |
| Creating Virtual Machines and vApps from Templates in a Content Library | 78 |

5 Configuring Virtual Machine Hardware 88

| | |
|---|-----|
| Virtual Machine Compatibility | 88 |
| Virtual CPU Configuration | 97 |
| Virtual Memory Configuration | 104 |
| Virtual Disk Configuration | 110 |
| SCSI and SATA Storage Controller Conditions, Limitations, and Compatibility | 121 |
| Virtual Machine Network Configuration | 128 |
| Other Virtual Machine Device Configuration | 143 |
| USB Configuration from an ESXi Host to a Virtual Machine | 156 |
| USB Configuration from a Client Computer to a Virtual Machine | 165 |
| Add a Shared Smart Card Reader to Virtual Machines | 172 |
| Securing Virtual Machines with Virtual Trusted Platform Module | 173 |

6 Configuring Virtual Machine Options 176

| | |
|--|-----|
| Virtual Machine Options Overview | 176 |
| General Virtual Machine Options | 177 |
| Configuring User Mappings on Guest Operating Systems | 179 |
| VMware Remote Console Options | 182 |
| Configure Virtual Machine Encryption Options | 182 |
| Virtual Machine Power Management Options | 185 |
| Configuring VMware Tools Options | 186 |
| Virtualization Based Security | 188 |
| Configuring Virtual Machine Boot Options | 190 |
| Configuring Virtual Machine Advanced Options | 192 |
| Configure Fibre Channel NPIV Settings | 195 |

7 Managing Multi-Tiered Applications with vSphere vApp 197

| | |
|---|-----|
| Create a vApp | 198 |
| Perform vApp Power Operations | 199 |
| Create or Add an Object to a vApp | 200 |
| Clone a vApp | 200 |
| Edit vApp Notes | 201 |
| Configure vApp Properties | 201 |
| Configure vApp Properties in the vSphere Web Client | 202 |
| Edit vApp Settings | 203 |
| Add a Network Protocol Profile | 209 |
| Virtual Machine vApp Options | 214 |

| | | |
|-----------|--|------------|
| 8 | Monitoring Solutions with the vCenter Solutions Manager | 222 |
| | View Solutions | 222 |
| | vSphere ESX Agent Manager | 223 |
| 9 | Managing Virtual Machines | 226 |
| | Installing a Guest Operating System | 227 |
| | Customizing Guest Operating Systems | 229 |
| | Edit Virtual Machine Startup and Shutdown Settings in the vSphere Web Client | 242 |
| | Edit Virtual Machine Startup and Shutdown Settings | 244 |
| | Install the VMware Enhanced Authentication Plug-in | 246 |
| | Using a Virtual Machine Console | 247 |
| | Answer Virtual Machine Questions | 248 |
| | Removing and Reregistering VMs and VM Templates | 249 |
| | Managing Virtual Machine Templates | 251 |
| | Using Snapshots To Manage Virtual Machines | 253 |
| | Enhanced vMotion Compatibility as a Virtual Machine Attribute | 265 |
| | Virtual Machine Storage DRS Rules | 269 |
| | Migrating Virtual Machines | 272 |
| 10 | Upgrading Virtual Machines | 293 |
| | Downtime for Upgrading Virtual Machines | 294 |
| | Upgrade the Compatibility of a Virtual Machine Manually | 295 |
| | Schedule a Compatibility Upgrade for a Virtual Machine | 296 |
| 11 | Required Privileges for Common Tasks | 298 |
| 12 | Troubleshooting Overview | 301 |
| | Guidelines for Troubleshooting | 301 |
| | Troubleshooting with Logs | 303 |
| 13 | Troubleshooting Virtual Machines | 305 |
| | Troubleshooting USB Passthrough Devices | 305 |
| | Recover Orphaned Virtual Machines | 306 |
| | Virtual Machine Does Not Power On After Cloning or Deploying from Template | 307 |

About vSphere Virtual Machine Administration

vSphere Virtual Machine Administration describes how to create, configure, and manage virtual machines in the VMware vSphere® environment.

This guide provides introductions to the tasks that you can perform within the system and also cross-references to the documentation that describes the tasks in detail.

This information focuses on managing virtual machines and includes the following information.

- Creating and deploying virtual machines, templates, and clones
- Deploying OVF templates
- Using content libraries to manage templates and other library items
- Configuring virtual machine hardware and virtual machine options
- Managing multi-tiered applications with VMware vSphere vApp
- Monitoring solutions with the vCenter Solutions Manager
- Managing virtual machines, including using snapshots
- Upgrading virtual machines
- Troubleshooting virtual machines

vSphere Virtual Machine Administration covers VMware ESXi™ and VMware vCenter Server®.

Intended Audience

This information is written for experienced Windows or Linux system administrators who are familiar with virtualization.

vSphere Web Client and vSphere Client

Instructions in this guide reflect the vSphere Client (an HTML5-based GUI). You can also use the instructions to perform the tasks by using the vSphere Web Client (a Flex-based GUI).

Tasks for which the workflow differs significantly between the vSphere Client and the vSphere Web Client have duplicate procedures that provide steps according to the respective client interface. The procedures that relate to the vSphere Web Client, contain vSphere Web Client in the title.

Note In vSphere 6.7 Update 1, almost all of the vSphere Web Client functionality is implemented in the vSphere Client. For an up-to-date list of any remaining unsupported functionality, see [Functionality Updates for the vSphere Client](#).

Updated Information

This *vSphere Virtual Machine Administration* guide is updated with each release of the product or when necessary.

This table provides the update history of the *vSphere Virtual Machine Administration* guide.

| Revision | Description |
|-------------|---|
| 22 FEB 2019 | Added a note in Create a Customization Specification for Windows Using a Custom Sysprep Answer File to document the cases when the custom network settings that are selected during the creation of the customization specification are not applied to the virtual machine. |
| 04 FEB 2019 | Updated Step 3 in Determine the EVC Mode of a Virtual Machine with information about the case when a virtual machine is not in an EVC cluster and does not have per-VM EVC configured. |
| 16 JAN 2019 | Minor revisions. |
| 13 DEC 2018 | <ul style="list-style-type: none"> Removed the information that virtual machines with VMware Paravirtual SCSI controllers cannot be part of an MSCS cluster in SCSI and SATA Storage Controller Conditions, Limitations, and Compatibility. Added videos in The vSphere Client and the vSphere Web Client and Creating and Managing Customization Specifications about the interface improvements and changes in the HTML 5-based vSphere Client. |
| 16 OCT 2018 | Initial release. |

Introduction to VMware vSphere Virtual Machines

1

A virtual machine is a software computer that, like a physical computer, runs an operating system and applications. The virtual machine consists of a set of specification and configuration files and is backed by the physical resources of a host. Every virtual machine has virtual devices that provide the same functionality as physical hardware but are more portable, more secure, and easier to manage.

Before you start creating and managing virtual machines, you benefit from some background information, for example, the virtual machine files, life cycle, components, and so on.

This chapter includes the following topics:

- [Virtual Machine Files](#)
- [Virtual Machines and the Virtual Infrastructure](#)
- [Virtual Machine Lifecycle](#)
- [Virtual Machine Components](#)
- [Virtual Machine Hardware Available to vSphere Virtual Machines](#)
- [Virtual Machine Options](#)
- [The vSphere Client and the vSphere Web Client](#)
- [Where to Go From Here](#)

Virtual Machine Files

A virtual machine consists of several files that are stored on a storage device. The key files are the configuration file, virtual disk file, NVRAM setting file, and log file. You configure virtual machine settings through the vSphere Client, one of the vSphere command-line interfaces (PowerCLI, vCLI), or the vSphere Web Services SDK.

Caution Do not change, move, or delete virtual machine files without instructions from a VMware Technical Support representative.

Table 1-1. Virtual Machine Files

| File | Usage | Description |
|-------|---------------------|--|
| .vmx | <i>vmname</i> .vmx | Virtual machine configuration file |
| .vmxf | <i>vmname</i> .vmxf | Additional virtual machine configuration files |

Managing Multi-Tiered Applications with vSphere vApp

7

With vSphere vApp, you can package multiple interoperating virtual machines and software applications into a single unit that you can manage and distribute in OVF format.

A vApp can contain one or more virtual machines. Any operation carried out with the vApp, such as clone or power off, affects all virtual machines in the vApp container.

In the vSphere Web Client and the vSphere Client, you can navigate to the vApp **Summary** tab, where you can view the current status of the vApp, and you can manage the vApp.

Note Because the vApp metadata resides in the vCenter Server database, a vApp can be distributed across multiple ESXi hosts. The metadata information might be lost if the vCenter Server database is cleared or if the standalone ESXi host that contains the vApp is removed from the vCenter Server. Back up your vApps to an OVF package to avoid losing metadata.

vApp metadata for the virtual machines within the vApp does not follow the snapshot semantics for virtual machine configuration. The vApp properties that you delete, modify, or define after you take a snapshot of a virtual machine remain respectively deleted, modified, or defined, if the virtual machine reverts to that snapshot or any prior snapshots.

This chapter includes the following topics:

- [Create a vApp](#)
- [Perform vApp Power Operations](#)
- [Create or Add an Object to a vApp](#)
- [Clone a vApp](#)
- [Edit vApp Notes](#)
- [Configure vApp Properties](#)
- [Configure vApp Properties in the vSphere Web Client](#)
- [Edit vApp Settings](#)
- [Add a Network Protocol Profile](#)
- [Virtual Machine vApp Options](#)

Create a vApp

A vApp allows you to perform resource management and certain other management activities such as power operations for multiple virtual machines at the same time. You can think of the vApp as the container for the virtual machines, and you can perform the operations on the container.


When you create a vApp, you can add it to a folder, standalone host, resource pool, DRS cluster, or another vApp.

Prerequisites

Verify that one of those objects is available in your data center.

- A standalone host that is running ESX 4.0 or later
- A DRS cluster

Procedure

- 1 Start the **New vApp** wizard.
 - In the vSphere Client, right-click an object that supports vApp creation and click **New vApp**.
 - In the vSphere Web Client, right-click an object that supports vApp creation and select **New vApp** > **New vApp** .
- 2 On the Select creation type page, select **Create a new vApp** and click **Next**.
- 3 On the Select a name and location page, type a name and select a location for the vApp, and click **Next**.
 - If you start the creation process from a folder or vApp, you are prompted for a host, cluster, or resource pool.
 - If you start the creation process from a resource pool, host, or cluster, you are prompted for a folder or data center.
- 4 On the Resource allocation page, allocate CPU and memory resources to the vApp.

| Option | Description |
|-------------------------|---|
| Shares | Defines the CPU or memory shares for this vApp with respect to the parent's total. Sibling vApps share resources according to their relative share values bounded by the reservation and limit. Select Low , Normal , or High , which specify share values respectively in a 1:2:4 ratio. Select Custom to give each vApp a specific number of shares that expresses a proportional weight. |
| Reservation | Defines the guaranteed CPU or memory allocation for this vApp. |
| Reservation Type | Defines whether the reservation is expandable. Select the Expandable check box to make the reservation expandable. When the vApp is powered on, if the combined reservations of its virtual machines are larger than the reservation of the vApp, the vApp can use resources from its parent or ancestors. |
| Limit | Defines the upper limit for this vApp's CPU or memory allocation. Select Unlimited to specify no upper limit. |

- 5 On the Review and finish page, review the vApp settings and click **Finish**.

Perform vApp Power Operations

One of the advantages of a vApp is that you can perform power operations on all virtual machines it contains at the same time.

When powering on a vApp within a DRS cluster in manual mode, no DRS recommendations are generated for virtual machine placements. The power-on operation performs as if DRS is run in a semiautomatic or automatic mode for the initial placements of the virtual machines. This does not affect vMotion recommendations. Recommendations for individual powering on and powering off of virtual machines are also generated for vApps that are running.

Prerequisites

Prerequisites depend on the task that you want to perform.

| Task | Required Privileges |
|------------------|------------------------------------|
| Power on a vApp | vApp.Power On on the vApp. |
| Power off a vApp | vApp.Power Off on the vApp. |
| Suspend a vApp | vApp.Suspend |

Procedure

- 1 Navigate to a vApp in the inventory.
- 2 Select one of the power operation options.

| Task | Action |
|------------------|--|
| Power on | <p>Right-click the vApp and select Power > Power On.</p> <p>You can power on a vApp to power on all its virtual machines and child vApps. Virtual machines are powered on according to the startup order configuration. If a delay is set in the startup settings of a virtual machine in the vApp, the vApp waits for the set length of time before powering on that virtual machine.</p> |
| Power off | <p>Right-click the vApp and select Power > Power Off.</p> <p>You can power off a vApp to power off all its virtual machines and child vApps. Virtual machines are powered off in reverse startup order. If a delay is set in the shutdown settings of a virtual machine in the vApp, the vApp waits for the set length of time before powering off that virtual machine.</p> |
| Suspend | <p>Right-click the vApp and select Power > Suspend.</p> <p>You can suspend a vApp to suspend all its virtual machines and child vApps. Virtual machines are suspended in the reverse order of the specified startup order. All virtual machines are suspended regardless of the Suspend behavior you specified in the Power Management VM Option for the virtual machine.</p> |
| Resume | <p>Right-click a vApp that is powered off or suspended and select Power On.</p> <p>Virtual machines are resumed according to their startup order configuration.</p> |

On the **Summary** tab, the **Status** indicates the vApp status.

Exhibits 17-25
redacted in their entirety

Exhibit 26

What's New in vRealize Operations 7.5? A Technical Overview, Part 1

John Dias (<https://blogs.vmware.com/management/author/jdias>) posted April 11, 2019

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Remember when you thought vRealize Operations 7.0 was a giant release packed with goodness? That was just the warm up. Welcome to vRealize Operations 7.5 (<https://www.vmware.com/products/vrealize-operations.html>) which contains so many new and improved features I will have to break this technical overview blog into four chunks, so you don't break your mouse's scroll wheel in one go.

Why four? Well, with the release of 7.5 we are matching the four tenets of Self-Driving Operations with the four pillars of use cases found on the Quick Start screen.



(<http://blogs.vmware.com/management/files/2019/04/vrops75quickstart.png>)

Each of these areas is gaining something new and exciting with 7.5, so I will break down this blog into a series that covers each of them, plus a bonus post on "The Best of the Rest" to round out things that help with overall usability which are still important things you should know.

Let's get started with the first pillar, Workload Optimization. If you need a review of what Workload Optimization is and how you can benefit from it, check out these demos (https://players.brightcove.net/1534342432001/S1xUFpuYwx_default/index.html?playlistId=5834402939001&autoplay=true)!

vSAN Aware Placement

Virtual machines running on vSAN datastores can now benefit from Workload Placement in vRealize Operations. This means Workload Placement can now migrate virtual machines between vSAN clusters to enforce Operational Intent (balance, moderate or consolidate virtual machines) and Business Intent (placement on hosts or clusters based on vSphere tagging). Specifically, the Workload Optimization is respectful of three aspects of vSAN that influence placement decisions:

- Storage Policy
- Slack Space

- Resync

Each of these is considered during a workload optimization event to insure to any moves will enhance workload performance and not create any bottlenecks.

As you know, vSAN requires each virtual machine to be assigned a storage policy. This provides a set of basic storage capabilities related to data availability and protection as well as capacity reservations. Workload Placement relies on vCenter to validate each virtual machine's storage policy against all available target vSAN datastores. Any vSAN datastores which can support the VMs storage policy are considered candidates for migration destination.

So, what is Slack Space? Since vSAN is a distributed storage solution, it needs free space to perform these actions that are transparent to the user. Any of the changes listed will use this slack space temporarily to adjust to the new conditions. However, it cannot be deemed as capacity always used for temporary actions, since the resynchronizations may have occurred the result of the user prescribing a higher level of resilience. As such, vRealize Operations now understands how much slack space is needed by a vSAN datastore so it can be subtracted from the overall space available.

Finally, a resync can occur any time vSAN determines the need to do so. It protects the availability of data in accordance with virtual machine storage policies. This can create additional network IO on the cluster. Given that this important operation should not be interrupted or impacted by migrating virtual machines, Workload Optimization will avoid migration of virtual machines to vSAN clusters running resync.

A couple of things to keep in mind when using Workload Optimization in a vSAN environment:

1. In order to get the full benefits you will need to enable the vSAN mgmt pack. That's easy to do because it's native inside of vROps.
2. Workload Placement will not migrate a virtual machine from vSAN to a datastore cluster or vice-versa (e.g. it will only move a vSAN VM to another vSAN cluster).

Host Group Visualization of Usage

In 7.5 we have enhanced the Workload Optimization cluster details to show host groups created through the Business Intent settings. For example, if you use Business Intent to enforce placement of virtual machines on specific hosts for license cost reduction, Workload Optimization automatically creates host groups in DRS (as well as virtual machine groups).

Now, you can dig deeper into cluster utilization to see how each of the host groups is using CPU and memory.

Are your clusters meeting your utilization objective?

[VIEW DRS SUMMARY](#) [SET DRS AUTOMATION](#)

| Name | CPU Workload % | Memory Workload % |
|---------------------------------------|----------------|-------------------|
| Host Licensing Cluster 02 | 79% | 65% |
| HostGroup - License Enforcement-Linux | 88% | 63% |



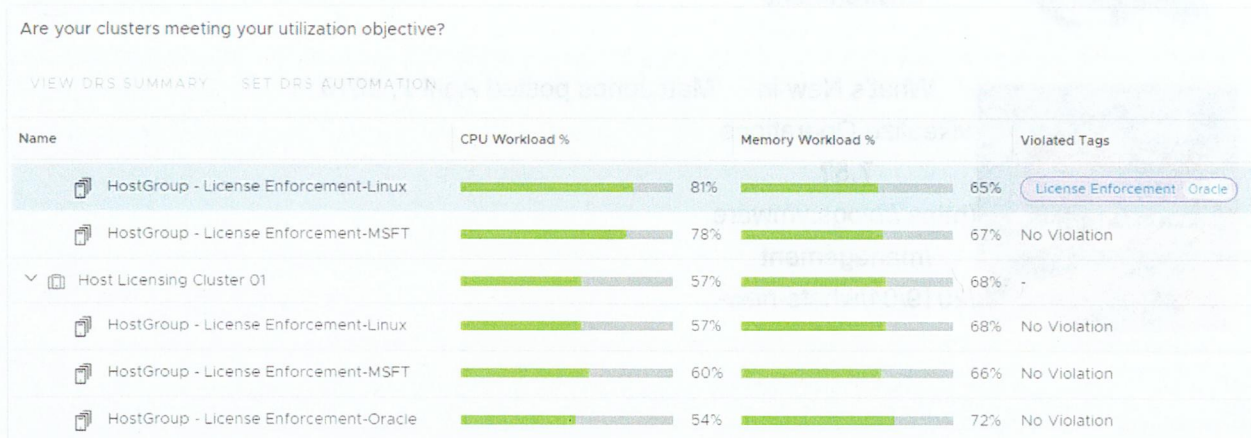
(<http://blogs.vmware.com/management/files/2019/04/Part-1-pic-2.png>)

For example, in the screenshot above there are two clusters in this datacenter. The datacenter itself is set to an Operational Intent of “Balance” and a Business Intent for Host Based License Enforcement. The clusters themselves are balanced well, however that does not mean everything is running smoothly. Notice that the Linux host group on cluster 02 is showing very high CPU workload, while the Linux host group in cluster 01 has much lower CPU workload. The datacenter needs to be optimized to alleviate this high workload on the Host Group. Running Workload Optimization will migrate Linux virtual machines from cluster 02 to cluster 01, ensuring they stay within the appropriate Host Groups and honoring license enforcement.

If a cluster is constrained and cannot meet Operational Intent due to restrictions placed by Business Intent (for example, both Linux host groups above are CPU constrained), then you can see where the bottleneck is within host groups and decide which of them needs more resources (then you can run a What-If scenario to plan for more hosts).

Simplified Violation Visualizations

Along with host group visibility, you can now get more specific detail on Business Intent tag violations. Previously, in Workload Optimization, you would only see the tag involved in the violation at the datacenter level. Helpful, but it would be better to know which objects are triggering the violation. Now, you can easily find out which virtual machines aren’t where they need to be according to your Business Intent.



(<http://blogs.vmware.com/management/files/2019/04/Part-1-pic-3.png>)

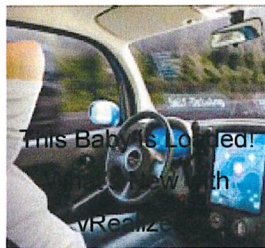
Returning to our license enforcement use-case for Business Intent, the screenshot above shows there is a virtual machine tagged with “Oracle”, yet it is running on the host group for Linux. This gives you quick and easy understanding of the details that caused the tag violation instead of waiting until you run the optimization to view the moves. And in the event that the virtual machine cannot be

moved due to resource constraints (i.e. the host group is at 100% utilization for CPU or memory) you will at least know the impact to your Business Intent to help justify any additional purchases or reclaims that need to be made.

Try It For Yourself

A good way to learn more is to download a trial of vRealize Operations 7.5 (<https://www.vmware.com/go/vrealize-ops-dl-en>) and try it out! You can also find more demos and videos on vrealize.vmware.com (<https://vrealize.vmware.com>). Be sure to check out the next blog in this series where I will cover what's new in 7.5 in Optimize Capacity (<https://blogs.vmware.com/management/2019/04/whats-new-in-vrealize-operations-7-5-a-technical-overview-part-2.html>), including the return of the allocation model, discovery and reporting of orphaned disks, new What-If scenarios and more.

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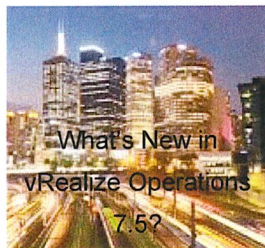


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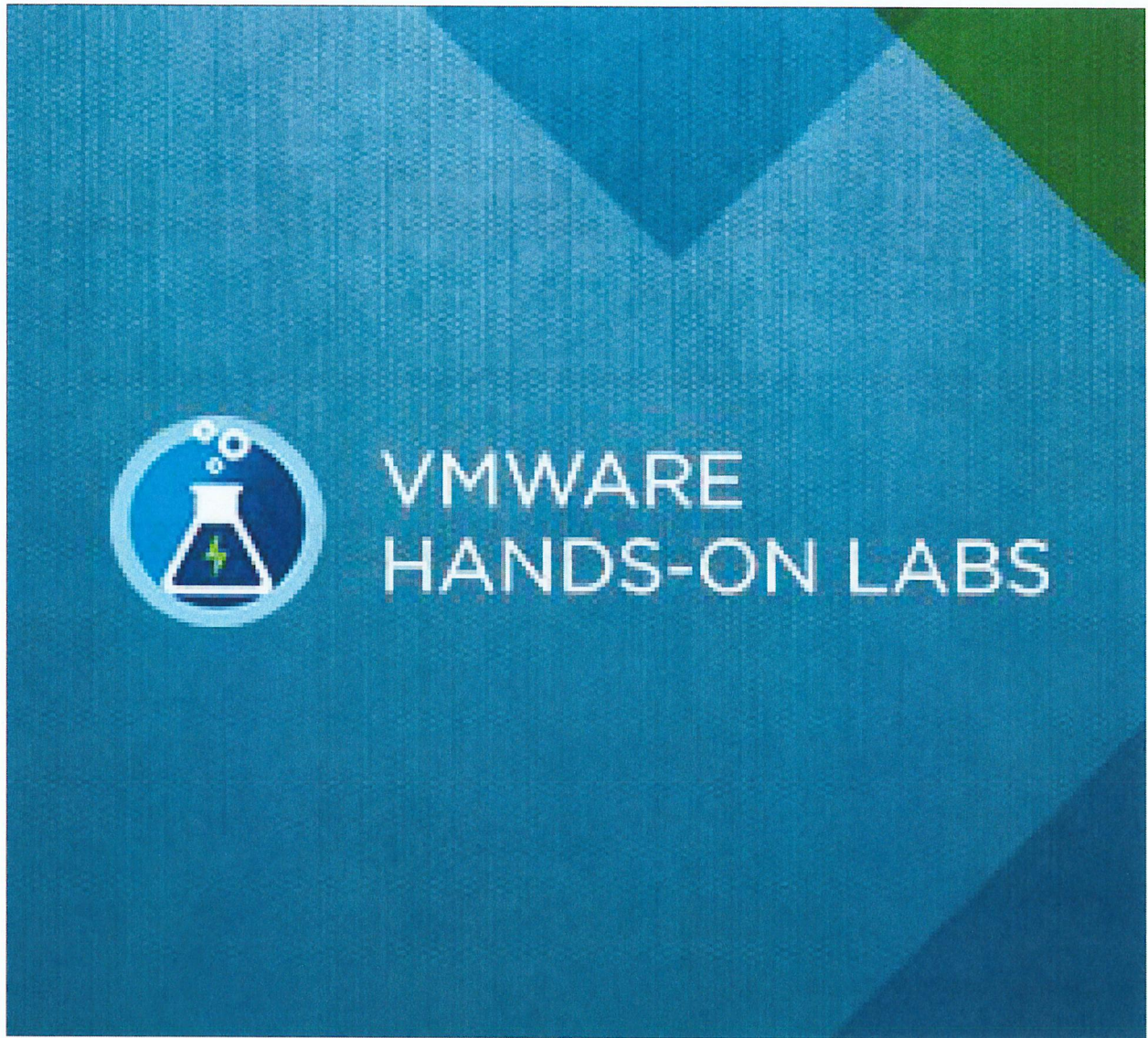


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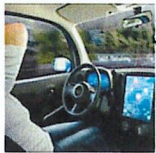
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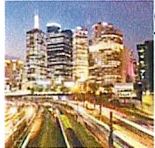
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Matt Jones posted April 2, 2019

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Exhibit 27

What's New in vRealize Operations 7.0

Taruna Gandhi (https://blogs.vmware.com/management/author/taruna_gandhi) posted August 27, 2018

4 Comments



Today, VMware announced the upcoming release of vRealize Operations 7.0, which will help customers derive even more value from a "Self-Driving" approach to operations management.

The **Self-Driving vision is to automate and simplify operations management** (<https://www.vmware.com/products/vrealize-operations.html>) by delivering per the "Three Tenets" of Self-Driving Operations.

1. Intent-Driven Continuous Performance Optimization
2. Efficient Capacity Management
3. Intelligent Remediation

What's New in vRealize Operations 7.0

As you will recall, we introduced self-driving operations in March this year, with the release of vRealize Operations 6.7. Self-driving summarizes the strategy and vision to provide continuous and automated closed loop performance and capacity optimization at minimal cost that is based on business and operational intent. Think about it, as a customer all you need to do is define operational and business intent, and let the platform take care of the rest to assure performance, densify clusters or enforce software license separation. Once intent is defined, the platform continuously verifies workload performance against defined intent, applying predictive analytics to project future requirements, and automatically takes actions to balance workloads and right-size VMs to optimize performance and capacity.

The upcoming vRealize Operations 7.0 will augment the capabilities introduced in the last release, particularly focusing on:

- **Business intent-driven continuous performance optimization** with new automated workload balancing capabilities, enhanced integration with vRealize Automation for both initial placement and on-going workload balancing, new host-based placement feature, and workload right-sizing workflows
- **Efficient capacity management** by enhancing the real-time, predictive capacity & cost analytics engine and adding multiple what-if planning scenarios
- **Multi-cloud** support with migration planning across VMware Cloud on AWS and native AWS, as well as updated management packs for AWS and Kubernetes
- **Quick time to value** with updates to the UI, simplified custom dashboard creation and sharing, enhanced SDDC integrations and built-in vSphere config & compliance

Learn more at VMworld: <https://blogs.vmware.com/management/2018/08/vmworld-las-vegas-recommended-self-driving-operations-sessions.html>

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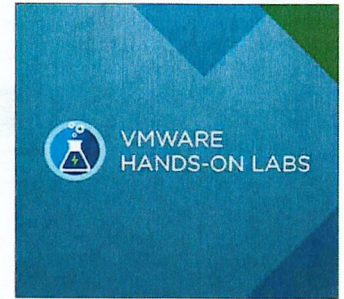
Let's double click into some of these capabilities.

Closed Loop Performance Optimization

With the upcoming vRealize Operations 7.0 release, VMware will enhance the integration between vRealize Operations and vRealize Automation to deliver closed loop performance optimization. Deep integration between vRealize Operations 7.0 and vRealize Automation 7.5 will enable full Cloud Management Platform (CMP) integration for **initial and ongoing placement** of workloads across clusters based on operational and business intent (e.g., utilization, compliance, license cost)

vRealize Automation can already take advantage of the analytics and intent from vRealize Operations for best initial placement of workloads, provisioning new deployments based on available capacity and usage trends. Now let's say some time passes and either vRealize Operations finds an opportunity to

PROMO



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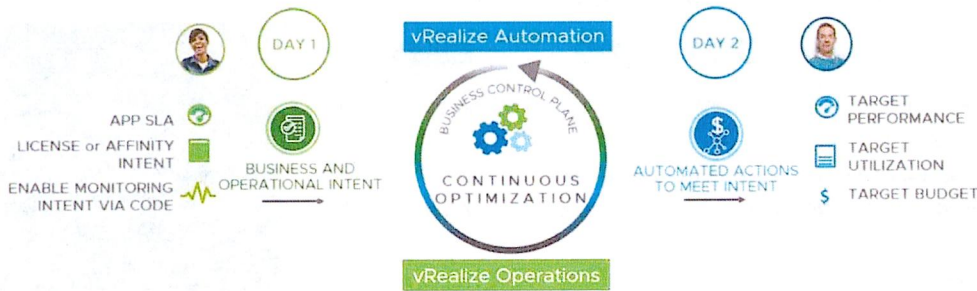


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optimize performance or a datacenter goes red, indicating resource imbalance. vRealize Operations will honor the reservation policies for placement and balancing and only migrate virtual machines between clusters which are part of the same reservation.



pivotal-container-servicepks-using-vmware-wavefront-and-vrealize-operations.html)

Alka Gupta posted August 6, 2018

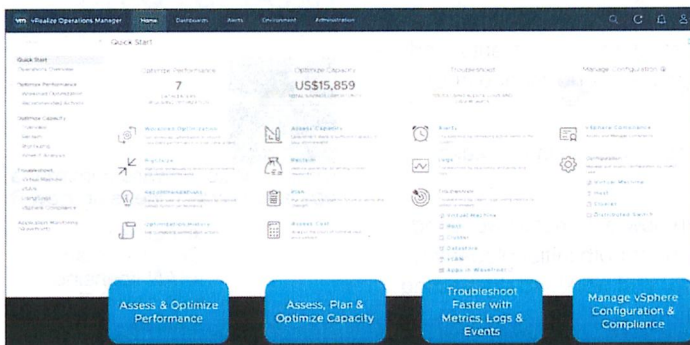


(<https://blogs.vmware.com/mana-driving-operations-whats-new-vr7.html>)

Key Highlights of vRealize Operations 7.0

1. Enhanced User Interface

The new release will make vRealize Operations even simpler to use, featuring an updated use case and persona-based 'Quick Start' dashboard.

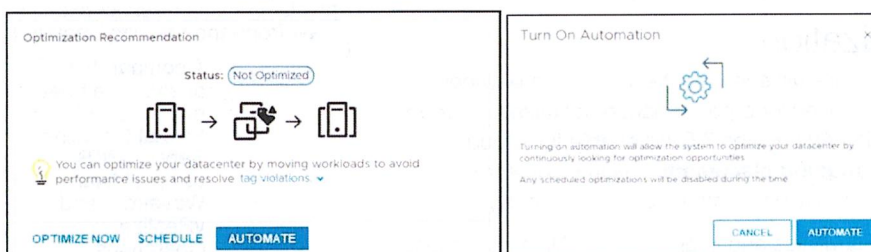


Self-driving Operations: What's New in vRealize Operations 6.7 (<https://blogs.vmware.com/mana-driving-operations-whats-new-vrealize-operations-6-7.html>)

Taruna Gandhi posted March 29, 2018

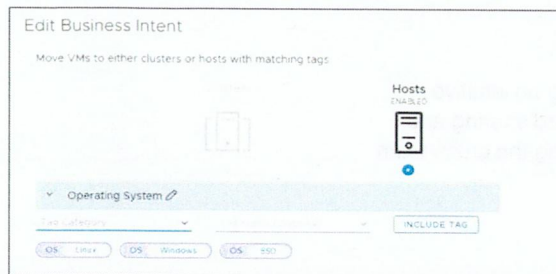
2. Automating Performance Based on Business and Operational Intent

In the previous release of vRealize Operations 6.7, we introduced performance optimization based on intent. In this release of vRealize Operations 7.0, we are enhancing this capability by introducing the **Automate** button. When the **Automate** button is selected, vRealize Operations will automatically search for optimization opportunities and execute accordingly. Customers will still have the options to trigger optimization actions immediately and manually or schedule it to occur in a convenient maintenance window.



3. Automated Host Based Placement, Driven by Business Intent

This new capability will provide customers a way to automate Distributed Resource Scheduler (DRS) based on business intent. Typically, vRealize Operations balances workloads across clusters and DRS resolves contention within the cluster. Now, you will be able to teach DRS your business intent and control not only balancing across clusters, but also which host within a cluster the workload will land on. This can be used for license separation, compliance, tiering and more. For example, if you have two clusters in a datacenter or custom datacenter, you will be able to specify which hosts are for Windows workloads, Linux, or MySQL and vRealize Operations will balance workloads across these clusters while ensuring that Windows workloads land on Windows hosts, Linux on Linux hosts ... you get the picture. You will also be able use this capability to fix tag violations and even segment a single giant cluster and manage license separation.



4. Capacity Analytics Enhanced with Exponential Decay and Calendar Awareness

The new capacity analytics engine delivered in vRealize Operations 6.7 was groundbreaking. We've continued to build from that momentum in vRealize Operations 7.0 with additional enhancements, particularly with **Exponential Decay and Calendar Awareness**.

Delivered in vROps 6.7

- Real-Time Predictive Capacity Analytics, based on industry-standard ARIMA statistical analysis model
- Improved capacity accuracy; including for Workload Optimization (aka Workload Balancing)
- Self-learning, updated in real-time; calculations available immediately
- Integrated costing with capacity

What's New in vROps 7.0

- Exponential decay to give more relevance to changing patterns and react better to more recent spikes without losing periodicity
- Improved calendar aware periodicity to detect, the n^{th} day of the month, the end of the month, and the first day of the month



5. Plan Capacity across Private Cloud and VMware Cloud on AWS

The **What-If Analysis** feature from vRealize Operations 7.0 can potentially help make room for new applications, procure hardware or migrate workloads to the cloud. The new release will offer three what-if scenarios to:

- **Workload Planning** to figure out the best fit for these new VMs
- **Physical Infrastructure Planning** to model hardware purchases with CapEx visibility
- **Migration Planning** helps plan cloud migration to VMware Cloud on AWS or AWS natively with detailed drill downs into costs and capacity requirements and recommendations

What-If Analysis

New Scenario

Workload Planning



Use this scenario for expanding or adding an application. Determine if the new VMs will fit into your environment.

SELECT

Physical Infrastructure Planning



Add to the capacity from your environment and determine how much hardware to purchase.

SELECT

Migration Planning

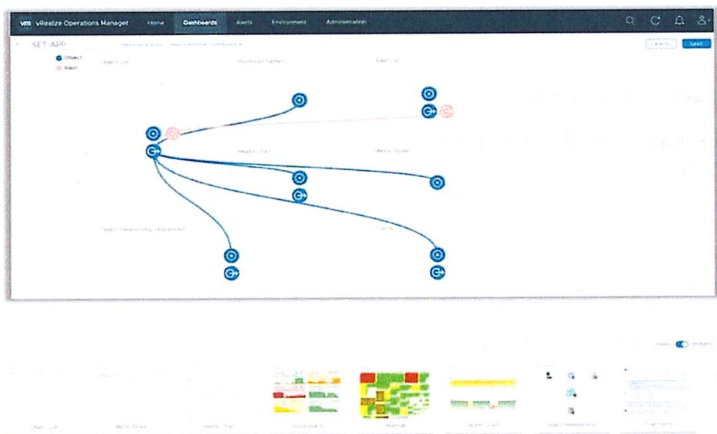


Evaluate the possibility of moving workloads across different clouds.

SELECT

6. Simplified Dashboard Creation and Sharing

In vRealize Operations 7.0, we've simplified the **dashboard creation** process, adding an intuitive canvas and multiple out of the box widgets to improve the user experience. Dashboard sharing and embedding will also become easier using smart links without requiring login, improving the cross-team collaboration and reporting for users.



7. vRealize Operations AWS Management Pack Update

Leveraging the updated AWS management pack, you will be able to manage your AWS inventory across regions and accounts and check the availability of AWS services, with **28 new dashboards**, summary pages and **34 new alerts**. You will also be able to reclaim unused AWS resources and get recommendations on EC2 instance types. You will have support for 24 AWS services, including EC2, RDS, EBS, LB, Lambda, Redshift, etc.

3. Cloudformation Stack Topology



8. Other Miscellaneous Enhancements

- **Workload Right-sizing** to avoid performance bottlenecks and reclaim over-allocated resources
- Built-in **vSphere config & compliance**: PCI, HIPAA, DISA, FISMA, ISO, CIS
- Ability to extend to the **entire data center** and cloud with updated management packs for Storage, vRO, Kubernetes, Federation etc.

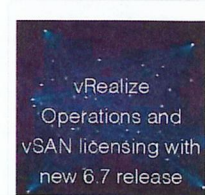
- vSAN performance, capacity, and troubleshooting including support for stretched clusters and through vRealize **Operations plug-in in vCenter**
- **Wavefront integration** for application operation
- .. And More!

These are just some of the highlights of the new release. Stay tuned for General Availability announcement.

For more information, take the guided tour: <https://www.vmware.com/go/vrealize-guides>
(<https://www.vmware.com/go/vrealize-guides>)

Visit the vRealize Operations home page: <https://www.vmware.com/products/vrealize-operations.html>
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COMMENTS

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Adam Bluhm
August 27th, 2018

Very exciting spotlight features and enhancements!

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How to embed vRealize Operations dashboards for easy information sharing. – VMware News and Updates (<https://www.marc-haines.com/how-to-embed-vrealize-operations-dashboards-for-easy-information-sharing/>)

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